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ABSTRACT

Warnings are coming from business leaders on a critical labor shortage, especially in information technology; however, representation of women, minority groups, and persons with disabilities in the U.S. science, engineering, and technology (SET) workforce could be improved. Preparing the nation for the evolving nature of work is important as well as providing an adequate number of SET workers. This document presents the recommendations of the Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development which are based on examinations of the barriers that exist for underrepresented minority groups, people with disabilities, and women in different levels of the SET pipeline. The recommendations focus on these points: (1) Precollege Education; (2) Access to Higher Education; (3) Professional Life; (4) Public Image; and (5) Nationwide Accountability. (Contains six pages of endnotes.) (YDS)

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Land of Plenty

Diversity as America's Competitive Edge in Science, Engineering and Technology

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September 2000

Report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development

SE064143

Land of Plenty

Diversity as America's Competitive Edge in Science, Engineering and Technology

September 2000

Report of the Congressional Commission on the Advancement of Women
and Minorities in Science, Engineering and Technology Development

**The Congressional Commission on the Advancement of
Women and Minorities in Science, Engineering and
Technology Development**

September, 2000

Dear President Clinton, Congresswomen Morella, and Esteemed Members of Congress and the National Governors' Association:

Today's U.S. economy depends more than ever on the talents of skilled, high-tech workers. To sustain America's preeminence we must take drastic steps to change the way we develop our workforce. An increasingly large proportion of the workforce consists of women, underrepresented minorities, and persons with disabilities—groups not well represented in science, engineering, and technology (SET) fields. Unless the SET labor market becomes more representative of the general U.S. workforce, the nation may likely face severe shortages in SET workers, such as those already seen in many computer-related occupations.

To address the problems facing America's scientific, engineering, and technological enterprise, Congresswoman Constance A. Morella developed and sponsored legislation creating the Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. In this legislation, the Commission was mandated to analyze and describe the current status of women, underrepresented minorities, and persons with disabilities in the science, engineering, and technology pipeline, beginning in early education classrooms and progressing through the SET pipeline to professional life in industry, government, and academe. Additionally, the Commission was instructed to develop and issue recommendations regarding the recruitment, retention, and advancement of women, underrepresented minorities, and persons with disabilities in SET education and careers.

In fulfillment of our mandate, the Commission is pleased to present our final report, *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. In compiling this report, the Commission conducted a comprehensive review of existing education and workforce data, past reports, and current trends, and commissioned new papers where there were gaps in the literature. Testimony was presented during public hearings by experts in the SET policy arena, by educators at all levels, corporate executives, government officials, and nonprofit sector leaders. The outcome of the Commission's efforts is a carefully selected set of action-oriented recommendations designed to create systemic change that is national in scope and structured for immediate implementation.

Growing the American talent pool requires a nationwide call to action and a major shift in how we educate, train, and recruit citizens in the fields of science, engineering, and technology. Barriers exist today throughout the SET pipeline that limit the number of women, underrepresented minorities, and persons with disabilities seeking and retaining these jobs. If we are to compete effectively in the global marketplace, we must advance the full and equitable participation of all Americans in science, engineering, and technology fields. Our economy will not only be positively affected by bringing more women, underrepresented minorities, and persons with disabilities into the SET workforce, but our high-tech, scientific, and engineering industries will benefit from their diverse viewpoints and approaches, as well as their skills.

We can and must reinvest in our people and work together to build a strong economic future that holds promise for all Americans. By establishing parity as our goal, we can increase the supply of skilled American workers and ensure that every American has a chance to rise with the economic tide.

Sincerely,

Elaine M. Mendoza *Commission Chair*	Kathryn O. Johnson, Ph.D. *Commission Vice-Chair*

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The Impact of the FMLA – Anne J. MacLachlan
Persons with Disabilities in Science, Engineering, and Technology: A White Paper Prepared for the Commission on Advancement of Women and Minorities in Science, Engineering, and Technology Development – Katherine D. Seelman
Effectiveness of Data Collection, Analyses, and Dissemination of NSF's Biennial Report, "Women, Minorities, and Persons with Disabilities in Science and Engineering" – Beatriz Chu Clewell

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EXECUTIVE SUMMARY

As we enter the twenty-first century, U.S. jobs are growing most rapidly in areas that require knowledge and skills stemming from a strong grasp of science, engineering, and technology. In some quarters—primarily information technology—business leaders are warning of a critical shortage in skilled American workers that is threatening their ability to compete in the global marketplace.

Yet, if women, underrepresented minorities, and persons with disabilities were represented in the U.S. science, engineering, and technology (SET) workforce in parity with their percentages in the total workforce population, this shortage could largely be ameliorated. Equally important as an adequate number of science, engineering, and technological workers is the nation's ability to prepare for the evolving nature of work of the future, including jobs as yet unimagined.

Now, more than ever, the nation needs to cultivate the scientific and technical talents of all its citizens, not just those from groups that have traditionally worked in SET fields. Women, minorities, and persons with disabilities currently constitute more than two-thirds of the U.S. workforce.[1] It is apparent that just when the U.S. economy requires more SET workers, the largest pool of potential workers continues to be isolated from SET careers.

> "Until our scientific and technological workplace reflects our diversity, we are not working to our potential as a nation."
>
> **Constance A. Morella**
> *Member, U.S. House of Representatives*
> *8th District, Maryland*

The Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (the Commission) spent over a year examining the barriers that exist for women, underrepresented minorities, and persons with disabilities at different stages of the SET pipeline. The Commission conducted a comprehensive review of existing workforce data, past reports, and current trends, and commissioned new papers where there were gaps in the literature. Testimony was presented by experts in the science and technology policy arena, educators at all levels, corporate executives, government officials, and nonprofit sector leaders. The outcome is a carefully selected set of action-oriented recommendations designed to create systemic change that is national in scope and structured for immediate implementation. The Commission strongly believes that if the nation is willing to make the investment called for by these recommendations, our workforce will be strengthened for the foreseeable future. As studies have shown, appropriate investment in preparing the workforce yields approximately four or five to one returns in economic benefits to the nation.[2,3]

If, on the other hand, the United States continues failing to prepare citizens from all population groups for participation in the new, technology-driven economy, our nation will risk losing its economic and intellectual preeminence. It is time to move beyond a mere description of the problem toward implementation of a national agenda that will take us where we must go, so that our nation can thrive now, and in the years to come. It is time also to establish clear lines of responsibility and to define effective accountability mechanisms.

The Commission's recommendations are as follows:

Precollege Education

The Problem: Inadequacies in the precollege environment have a major impact on each of the underrepresented groups. A serious deficiency in educational resources (e.g., well-prepared teachers, physical infrastructure, technological resources, and curriculum standards) prevents access to high-quality science and mathematics education for underrepresented minority students. Active discouragement and the dearth of out-of-school SET experiences and role models contribute to girls' lack of interest in SET careers. Poor access to well-prepared teachers, the built environment,[i] assistive technologies, and personal assistance deter students with disabilities from full participation in mathematics and science courses.[4]

The Recommendation: **The Commission recommends the adoption and implementation of comprehensive high-quality education standards, at the state level, concerning mathematics and science curricula, mathematics and science teacher qualifications (as recommended by the Glenn Commission), technological assets, built environments, assistive technologies, and physical infrastructure.**

- The National Commission on Mathematics and Science Teaching for the Twenty-First Century (the Glenn Commission) is addressing issues related to the national shortage of qualified mathematics and science teachers, and is creating action strategies to improve the quality of teaching in mathematics and science at all grade levels nationwide, and to ensure that an adequate supply of highly skilled mathematics and science educators enter and remain in teaching.
- The Commission recommends that all states adopt and enact legislation requiring school districts to collect achievement data on students disaggregated by socioeconomic status, limited English proficiency, disability status, race/ethnicity, and sex, and should hold districts, school boards, and schools accountable for the success of all subgroups in meeting state achievement standards.

Access to Higher Education

The Problem: Members of underrepresented groups exit in large numbers at different transition points in the mathematics and science pipeline. At the transition from high school to college, a large percentage of highly capable underrepresented minority students is forced out of the pipeline because of a lack of high-quality science and mathematics preparation in high school. Women—because of social pressure resulting from the negative social image of scientists and engineers,and because of lack of encouragement (coupled with active discouragement)—become diverted from interest in SET majors. The absence of persons with disabilities from media images of scientists and engineers and the general lack of assistive technologies discourage this group of individuals from entering college with a SET major. At the two-year college level, poor articulation with four-year colleges impedes the smooth transition of SET students to four-year institutions of higher education.[ii]

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[i] The built environment includes public and private buildings, tools and objects of daily use, and roads and vehicles. The environment is created by architects, industrial designers, planners, builders, and engineers.

The rising costs of college tuition and the deficiency of scholarships and grants available to students have reduced the prospect of a college education, especially for low-income students. A compelling national need now exists, requiring increased government investment in national talent to meet the shortage of workers in SET.

Recommendation #1: **The Commission recommends aggressive, focused intervention efforts targeting women, underrepresented minority, and disabled students at the high school level, at the transition into postsecondary education, and at the community college transition into four-year colleges and universities.**

- ➢ High School Level: The Commission recommends the expansion and institutionalization of successful school-based and nonschool-based enrichment programs to (a) identify—through the use of authentic, nontraditional assessments that account for the differential experiences of students—potentially able students from underrepresented groups that have been plagued by inadequate educational opportunities; and (b) enroll them in accelerated academic preparation programs. Federal, state, and local partnerships should be established to identify and fund these intervention programs at an appropriate level.
- ➢ Community College: Community colleges enroll close to half of all students that are traditionally underrepresented in SET. The Commission recommends comprehensive and systemic institutional changes to strengthen SET education at two-year colleges and to facilitate transition of SET students from two-year colleges into four-year colleges.

Recommendation #2: **The Commission recommends that the federal and state governments significantly expand financial investment in support of underrepresented groups in SET higher education, as well as institutions including, but not limited to, Minority Serving Institutions (Historically Black Colleges and Universities—HBCUs; Hispanic Serving Institutions—HSIs; and Tribal Colleges and Universities—TCUs). Expansion of support to students should come through multiple grant mechanisms rather than loans, to include scholarships, fellowships, and internships. Expansion of support to institutions should include institutional awards, research assistantships, traineeships, and the expansion of proven programs.**

- ➢ The Commission recommends that the federal government enact legislation to expand funding of the Pell Grant Program for SET students and SET education majors. It is recommended that the supplement have the same need requirements as the general Pell Grant, but effectually increase the maximum award to $6,418 for the students identified in this special-needs group. This amount would cover the same proportion of institutional fees that the Pell Grant did in 1979-80,[5] and may have the effect of substantially increasing the incentive for students to pursue SET careers.

[ii] Articulation is the facilitation of the transfer process from two-year to four-year educational institutions.

The measure of success is parity with respect to population distribution in enrollment, academic performance, and graduation rates of all groups at each level.

Professional Life

The Problem: The U.S. workplace culture needs to value differences more. The Commission recognizes that racial prejudice and ethnic and gender stereotypes are still pervasive in professional life. For women, underrepresented minorities, and people with disabilities these problems are manifested in inadequate work and family life accommodation, unequal pay scales and advancement, and non-inclusive behaviors in the SET workplace.

The Recommendation: **The Commission recommends that both public and private SET employers be held accountable for the career development and advancement of their employees who are women, underrepresented minorities, and persons with disabilities.**

- ➢ The Commission recommends that the degree of participation, comparative pay, level of pay at hire, career development, and advancement of women, underrepresented minorities, and persons with disabilities in the SET workplace be reported yearly.
- ➢ The Commission recommends that SET diversity be a strategic goal in the private, public,[iii] nonprofit, and academic sectors. It also recommends the adoption of policies promoting a workplace environment that is inclusive and respects diversity. The measure of success for diversity in the workplace is parity among all subgroups in SET employment, retention, and promotion rates.
- ➢ The Commission recommends the development of a system of high-level, prestigious awards in order to recognize exemplary achievement by organizations that encourage among their employees a healthy balance between their work and personal lives through flexible, functional workplace policies and attitudes.

A national model should be developed of a workplace environment that is inclusive, values differences, and has flexible workplace policies. The measure of ultimate success is parity relative to the general work force population distribution at different workplace and management levels, and equity in retention, pay, and promotion rates.

Public Image

The Problem: The public image of scientists, engineers, and technology workers is often both inaccurate and derogatory. In addition, women, underrepresented minorities, and persons with disabilities are not adequately portrayed by the media as participating in SET careers.

[iii] The Commission supports recommendation three of the April 2000 National Science and Technology Council report, "Ensuring a Strong U.S. Scientific, Technical, and Engineering Workforce in the Twenty-First Century." The recommendation urges that federal agencies "emphasize the recruitment of qualified individuals from ethnic and gender groups who are currently underrepresented in the ST&E workforce and vigorously pursue professional development opportunities for those already in the federal workforce."

The Recommendation: **Identify or establish a body, representing public, nonprofit, and private sectors, to coordinate efforts to transform the image of the SET professions and their practitioners so that the image is positive and inclusive for women, underrepresented minorities, and persons with disabilities.**

- Because several media campaigns to improve the image of scientists and engineers are already underway, our recommendation suggests that subsequent efforts build on and involve current campaigns, and also partner with natural allies such as underrepresented minority and women's groups, major science institutions, government agencies, trade organizations, and private foundations.

Sample measures of effectiveness include positive images represented in the Draw-a-Scientist Test, positive and increased media portrayal of underrepresented persons in science and engineering, and increased and well-positioned television airtime for these groups as they participate in SET professions.

Nationwide Accountability

The Problem: The lack of diversity in SET education and careers is an old dilemma, but economic necessity and workforce deficiencies bring a new urgency to the nation's strategic need to achieve parity in its SET workforce. Real progress demands a system of accountability so that the Commission's objectives can be met in a timely, effective manner.

The Recommendation: **Establish or identify a collaborative body to continue the efforts of the Commission through the development, coordination, and oversight of strong, feasible action plans.**

The responsibility of this continuing body will be to promote and monitor progress toward the Commission's goal of supplying our nation's SET work force needs through the development of the human resources represented by women, underrepresented minorities, and persons with disabilities. This collaborative body (whose members will include high-level persons from federal and state government, industry, academe, and the nonprofit sector, as well as students and teachers) will carry on the work of this Commission by developing and overseeing comprehensive action plans, and by securing resources that will help in reaching the Commission's goal of domestic work force parity in SET.

The continuing body has four charges:

- Develop action items to implement the recommendations developed by the Commission.
- Further develop appropriate existing programs, using the recommendations of the Commission as a point of reference.
- Coordinate and assign actions/programs to appropriate sectors (government, industry, academe), and ensure funding and resources.
- Monitor progress through ongoing data compilation and analysis.

This continuing body will be responsible for promoting and monitoring progress toward the Commission's goal of supplying our nation's SET workforce needs through the development of the human resources present in our women, underrepresented minorities, and persons with disabilities. This goal and the recommendations developed by the Commission will guide the body as to the types of actions to be undertaken, to whom the actions should be directed, and what entities are responsible for the actions. In this way, the new body will carry on the work of this Commission by developing and overseeing comprehensive action plans, and by securing resources that will help ßin reaching our goal of domestic workforce parity in SET.

INTRODUCTION

The Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (the Commission) was developed and sponsored by Congresswoman Constance A. Morella (R-MD), and established by Congress in 1998 (Public Law 105-255, approved October 14, 1998). Chief among the Commission's duties is to recommend a specific set of actions that will:

- advance the full and equitable participation of all Americans in science, engineering, and technology (SET) education;
- increase the number of qualified American scientists and engineers by expanding the human resources pool of women, members of racial and ethnic minority groups, and persons with disabilities; and
- thereby enhance the nation's economic capacity and technological growth in an era of global competitiveness.

Toward this end, the Commission strives to:

- broaden access to quality SET precollege education for all Americans, particularly underrepresented minorities;
- improve the preparation of women, underrepresented minorities, and persons with disabilities for access to higher education and increase the number of SET degrees earned by these populations; and
- increase the retention and reentry of women, underrepresented minorities, and persons with disabilities in SET education and the SET workforce.

Beginning in April 1999, Commission members (see page 81) held a series of meetings and public hearings at various sites spanning the nation[i] to consider written and oral testimony from more than 100 experts representing industry, government, academe, and the nonprofit sector. The Commission heard descriptions of the obstacles faced by women, underrepresented minorities, and persons with disabilities as they move through the SET pipeline, and examples of best practices and effective strategies for making SET education and careers more accessible (the Commission looked at "accessibility" broadly, intending not just that financial, social, and cultural impediments be removed, but that the built environment, as well as information and assistive technologies, allow full participation by anyone who is capable of contributing to the SET enterprise). The Commission examined past reports and current data, analyzed recent trends, and commissioned papers to fill in the gaps. The work of the Commission culminated in the set of recommendations that appear in the following sections of the report.

The section entitled "A National Imperative" reviews some of the data and analyses, and delineates the absolute imperative of the recommendations set forth by the Commission. The need for a highly skilled SET workforce is juxtaposed with the demographics of the population, which are becoming more and more diverse.

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[i] Meetings and public hearings of the Commission were held in a variety of locations. Thanks to the National Science Foundation, Arlington, VA; the National Institutes of Health, Bethesda, MD; and Bellevue Community College, Bellevue, WA, for hosting these important Commission events.

The current and imminent needs require a suite of strategies designed to establish parity in our domestic SET workforce.

The next three sections provide data describing the underrepresentation of women, minorities, and persons with disabilities in the various stages of the SET pipeline, beginning with the precollege grade levels, considering access to higher education, and continuing through professional life in industry, academe, and the federal government. The report discusses the barriers that impede women, underrepresented minorities, and persons with disabilities from being successful scientists, engineers, and technologists, and lay the groundwork for the Commission's recommendations for each pipeline stage. Minority groups currently underrepresented in the SET enterprise include African Americans, Hispanics, and American Indians. While certain segments of the Asian population are also underrepresented in SET, Asians as a whole are at least equitably represented in SET fields based on their numbers in the general workforce.

The "Public Image" section is devoted to an examination of how the public image of scientists, engineers, and technologists in the media might be improved so as to encourage more women, underrepresented minorities, and persons with disabilities to choose careers in SET fields. "Nationwide Accountability" suggests a mechanism of accountability by which the goals of the report may best be reached.

Each section includes one or two specific recommendations for addressing the issues described. Both short- and long-term, these recommendations include policies and programs that can be immediately implemented by Congress, federal departments and agencies, state government, the private sector, nonprofit organizations, and educational institutions. The recommendations call for a serious commitment of funds and other resources, but all promise a solid return on the investment.

At the heart of the recommendations is the goal of creating a domestic, highly skilled SET workforce in which women, underrepresented minorities and persons with disabilities participate on par with their representation in the U.S. workforce. By establishing parity as a major goal that can be used to measure accountability, the nation will simultaneously address two vital strategic needs: to boost the supply of skilled American workers and to ensure that every American has a chance to rise with the economic tide. Only then will the Commission fulfill its vision of a society that:

- enables access to, and achievement in, quality education and training in science, mathematics, engineering, and technology for all Americans;
- fosters a diverse, well-trained, and globally oriented workforce exemplified by innovation and productivity; and
- is committed to optimum utilization of all U.S. intellectual capital.

A NATIONAL IMPERATIVE

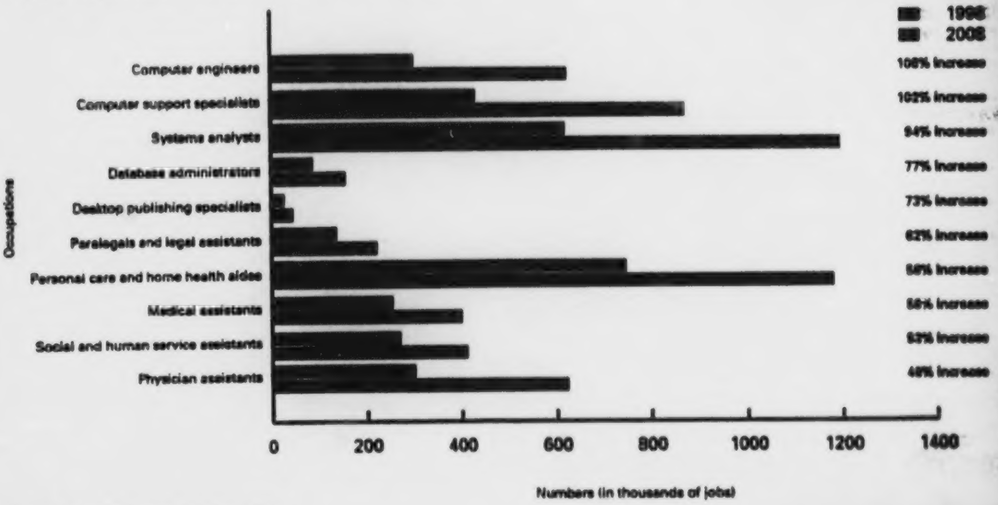
"Hiring, retaining, and developing great people is the biggest challenge and single greatest key to the success of any business."

Scott McNealy
CEO, Sun Microsystems

The United States' economy ranks among the best in the world, thanks in large part to a technological revolution that over the last fifty years has spawned unprecedented productivity and a host of new industries and jobs. In this climate, it is easy to lose sight of the fact that this new economy is especially dependent on, and thus vulnerable to, deficiencies in the talents and knowledge of the available workforce. Lester Thurow effectively argues that, "In the twenty-first century, the education and skills of the workforce will end up being the dominant competitive weapon."[1]

Success is ours today, but to sustain our preeminence we must take dramatic steps to change the way we engage the population in the new economy. Today, women, minorities, and persons with disabilities—groups that are chronically underrepresented in SET careers—constitute more than two-thirds of the overall workforce. At the same time, the Bureau of Labor Statistics tells us that professional specialty occupations, which include most scientists, engineers, and medical workers, are booming, having increased 31.7 percent between 1988 and 1998. Projections for 1998-2008 promise another growth spurt in this category (27 percent), with a need to fill 5.3 million new jobs.[2] In fact, of the top ten fastest growing occupations, the top five are computer related (see Figure 1).

Figure 1. Fastest Growing Occupations: 1998-2008



Source: Bureau of Labor Statistics, 1999.

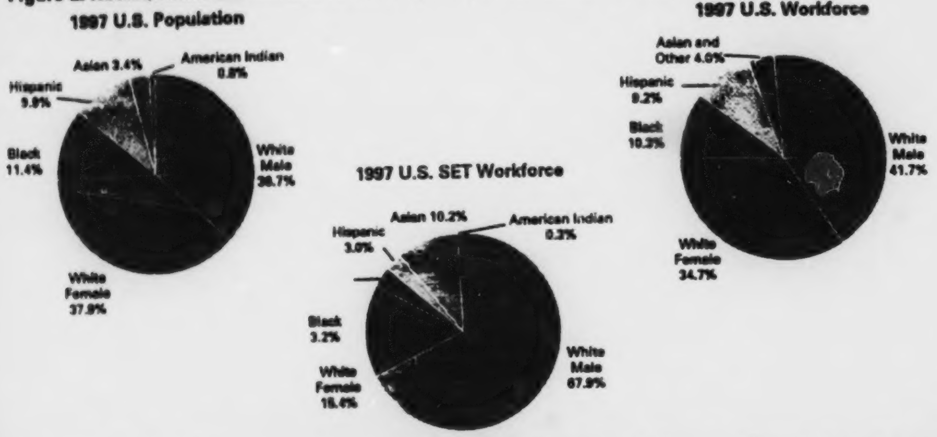
The business community is not alone in its need to develop and maintain a highly skilled, domestic SET workforce. Both academe and the federal government have a vested interest in finding ways to deepen their pools of science and technology educators and researchers. In addition to its interest in fostering economic productivity and growth, the federal government includes agencies with R&D programs that carry out essential goals of national importance (e.g., defense, environmental protection, space exploration, and health). These agencies need highly trained SET personnel to staff their programs. In 1995, the federal government employed 8 percent of all working scientists and engineers with a minimum of a bachelor's degree.[3]

Equally important as an adequate quantity of science, engineering, and technological workers is the nation's ability to prepare for the changing nature of work of the future. In the last decade alone, we have seen unprecedented and unanticipated changes in the nature of work itself in fields such as information technology and biotechnology. To ensure that the workforce of tomorrow possesses the necessary competencies and knowledge, and that all U.S. citizens are provided an opportunity for a bright future, we must train workers to succeed in jobs that are not yet imagined.

In addition, we must remain cognizant of the continuing need for the retraining of workers currently in the workforce. It is recognized that individuals in today's workforce will likely change the type of work that they do several times over the course of their careers.

If SET jobs are to be filled by the domestic workforce, then every U.S. citizen must be given an equal opportunity to acquire the skills and knowledge necessary to compete. And yet a disturbingly narrow range of citizens is now making its way through the SET pipeline. The SET workforce is comprised mainly of white males, with small percentages of women and minority group members (except Asians, who are overrepresented). Figure 2 shows the racial/ethnic distribution of the U.S.

Figure 2. Racial/Ethnic Distribution of U.S. Population, Workforce[i] and SET Workforce: 1997.



Sources: Population data—U.S. Census Bureau, *Statistical Abstract of the United States: 1998.* Workforce data—Bureau of Labor Statistics, retrieved from Historical Labor Force tables at http://stats.bls.gov/emplab1.htm. SET workforce data—tabulations by National Science Foundation/Science Resources Studies, SESTAT 1997.

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[i] The "Asian and Other" category in the 1997 U.S. Workforce graph covers both Asians and American Indians. BLS data do not disaggregate these two groups because the N is too small. Due to the small sample sizes for these populations, the percentage for "Asian and Other" may not be as accurate as the percentages for the other populations.

population in 1997 compared to the representation of these groups in the general workforce and the SET workforce. Persons with disabilities (who are not represented in Figure 2) make up approximately 20 percent of the population, 14 percent of the overall U.S. workforce, and 6 percent of the U.S. SET workforce.[4] Unless the SET workforce becomes more representative of the general U.S. workforce, the nation will undercut its own competitive edge in the future. That is, the competition for SET workers has already become global, and American companies that depend on importing talent will become increasingly vulnerable. In the words of Hudson Institute researchers, "The best jobs created in the Innovation Age will be filled by Americans…to the extent that workers possess the skills required to compete for them and carry them out. If jobs go unfilled in the U.S., they will quickly migrate elsewhere in our truly global economy."[5]

Americans can fill SET jobs if they are provided adequate education and stimulation. The problem is that existing industrial and educational programs are failing to attract and keep those U.S. citizens who make up an increasingly large share of the workforce: women, underrepresented minorities, and persons with disabilities, who together comprise approximately 70 percent of the U.S. workforce.[6]

The SET-related data on women and underrepresented minorities are more extensive than on persons with disabilities. With more consistent collection of comprehensive data will come a fuller understanding of the forces that inhibit these citizens' participation in SET careers. What we do know, however, is that technology has the capacity for improving access and participation of people even with severe disabilities. Access to built and virtual environments such as buildings, transportation, consumer products, and information technology is an important issue for this group. In science and technology fields, "access" includes access to laboratory and other specialized scientific equipment and computer analysis methods. People with disabilities will only be able to participate in SET if the tools created for these disciplines are universally designed.[ii][7]

Obviously, the current and projected need for more SET workers, coupled with the fact that women, underrepresented minorities, and persons with disabilities comprise an increasing proportion of the labor pool, argue for policies that support greater participation by these underrepresented groups in SET education and careers. Developing such policies requires that we take a serious look at the barriers preventing members of these groups from entering SET fields and learning critical workforce skills. In this report, the Commission identifies key barriers and makes recommendations for policies and actions that will build a diverse, domestic SET workforce capable of carrying the U.S. into an economically healthy future.

Europe Competes with U.S. for Workers

While opinions may differ about whether the U.S. is facing an across-the-board shortage of skilled workers, no one disputes that in at least one job category—computer technology—U.S. employers are scrambling to fill slots, even if it means hiring someone from outside the U.S.

But as reported in the May 5, 2000, issue of the *New York Times*, Europe—facing its own high-tech shortage—may be a tough competitor for skilled foreign workers. Estimated demand for technology professionals in Europe's four largest economies—Germany, England, France, and Italy—is expected to outpace supply. The shortage is particularly severe in Internet and Web-related businesses because European countries have failed to train enough workers of their own with high-technology skills.

Germany is the hardest hit: demand for high-tech employees is expected to exceed supply by up to 15 percent, or more than 400,000 jobs. The crunch is so acute that many European countries are overcoming their deeply entrenched resistance to immigration and crafting laws that will make it easier for companies to attract and retain high-tech employees, no matter what their native country.

"There is a war for talent," Olivier Gravelle, head of a French online job search company, told the *New York Times*. And with both the U.S. and European companies competing for workers from countries such as India, the war is heating up.

[ii] Universal design is a process whereby environments and products are designed to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.

Diversity Promotes Economic Success

Beyond the demographic reality that skilled workers must be drawn from an increasingly diverse domestic population, there are other compelling reasons why a workforce that includes more women, underrepresented minorities, and persons with disabilities helps to strengthen business, academe, and government. While the Commission recognizes the important social responsibility of the nation to develop an inclusive workforce and to provide opportunity for growth for all of its citizens, there is also factual evidence that businesses and other organizations see a significant return on their investment when diversity is achieved.

A recent survey of Fortune 100 human resource executives found that increasing diversity is desirable for the following five reasons: better utilization of talent; increased marketplace understanding; enhanced breadth of understanding in leadership positions; enhanced creativity; and increased quality of team problem-solving.[8] Another recent survey conducted by the American Management Association of more than one thousand of its members found that heterogeneity—a mixture of genders, ethnic backgrounds, and ages in senior management teams—consistently correlated with superior corporate performance in such areas as annual sales, growth revenues, market share, shareholder value, net operating profit, worker productivity, and total assets.[9]

In other words, the absence of women, underrepresented minorities, and persons with disabilities from the highest level of corporate management deprives corporations of diverse strategic skills and competencies in management that translate into economic gains. A culturally diverse workforce creates competitive advantage through greater creativity and innovation; increased organizational flexibility thanks to higher levels of divergent thinking; and better decision making based on multiple perspectives (less "group think") as well as a critical analysis of alternatives.[10] This competitive advantage holds true not just for American industry, but for the national scientific and engineering enterprise as a whole.

A diverse workforce also helps businesses reach a global market. For many firms, a growing proportion of their revenues comes from foreign sources, which heightens the need for U.S. businesses to understand the

The Workforce Gap in Silicon Valley

Business analysts point out that while the old economy hinged on suppliers, factories, and transportation, the new economy relies mostly on brainpower. Nowhere is this more evident than in Silicon Valley, cradle of the information technology revolution. In 1999, a nonprofit organization dedicated to the vitality of life in the region—Joint Venture: Silicon Valley Network—partnered with management consulting firm A.T. Kearney to conduct a study of how well Silicon Valley was meeting the demand for a diverse and skilled talent pool. The results, noted Rebecca Guerra, vice president of human resources for eBay, "represent a reality that Silicon Valley employers cannot afford to ignore."

The study[i] found that 31 to 37 percent of the workforce gap in the Silicon Valley high-tech industry resulted in an incremental cost of nearly $4 billion annually. Along with the high price of housing in the region and the difficulty that smaller companies had in paying top dollar for workers, survey respondents ranked the lack of qualified candidates as one of the top reasons for the shortage. Contributing to the problem was the finding that Silicon Valley students did not have the familiarity or interest in high-tech careers that might prompt them to build the necessary skills.

The study noted that efforts to address the workforce gap had so far been fragmented, short-term, and unlikely to sustain enough momentum for lasting change. To address the issues, the study called for a collaboration among Silicon Valley stakeholders—not only the region's 7,000 technology-based companies but also schools and colleges, nonprofit organizations, and industry associations. Among the study's recommendations were to link curriculum development in schools with particular high-demand skill clusters in business, and to expand the focus and scope of internship, externship, job mentoring, and cooperative education programs.

[i] Joint Venture: Silicon Valley Network, Inc. Joint Venture's Workforce Study: An Analysis of the Workforce Gap in Silicon Valley, San Jose, CA, 1999.

market preferences of different cultures. Employees with knowledge of other cultures become essential for firms that operate in a global context. Further, as minority populations constitute an increasing part of local markets, companies need the insight and cultural sensitivity that ethnic minorities can bring to marketing efforts.

Wanted: A Long-Term Labor Solution

A report issued by the Council on Competitiveness identifies an "acute skills shortage in every part of the country that threatens the foundation of American competitiveness."[11] The Council report cites a 1997 survey in which almost 70 percent of CEOs pointed to the skills shortage as the number one barrier to growth, and concludes that "unless U.S. firms can create 'home grown' technicians by increasing adult training opportunities and by expanding college graduates in computer and engineering programs, [companies] will move their operations abroad or import talent from overseas."[12]

Indeed, faced with a shortage of highly skilled SET workers, particularly in computer-related occupations, many businesses are resorting to recruiting foreign engineers and scientists and bringing them to the U.S. on H-1B visas. Congress raised the ceiling on H-1B visas from 65,000 to 115,000 for 1999, a ceiling that was reached by June 1999. However, reliance on foreign workers to fill domestic SET jobs is a stopgap solution. Training foreign workers in the U.S. may sharpen the competitive edge of other nations.[13] More importantly, the supply of foreign workers is uncertain. As other economically competitive nations evolve, the supply of foreign workers available to U.S. employers will decrease.

Diversity at Dow Chemical

William Stavropoulos, president and CEO of Dow Chemical Company, recognizes that to be successful in a world where most of the emerging markets are in Asia, Latin America, and Central and Eastern Europe, his company must "accept and embrace diversity." For him, this means not only having a workforce balanced by nationality, gender, and race, but also a workforce that can accept differences in style, manner, and experience.

"Our goal," states the company's brochure on diversity at Dow, "is not simply to track numbers, although that may be necessary, but to truly embrace diversity for the competitive asset that it is." More than 30 senior executives at Dow serve on the CEO Council on Diversity, which has conducted its first Global Cultural Survey to gather employee opinions on how well the corporate culture supports diversity, and is currently working on recommendations for change.

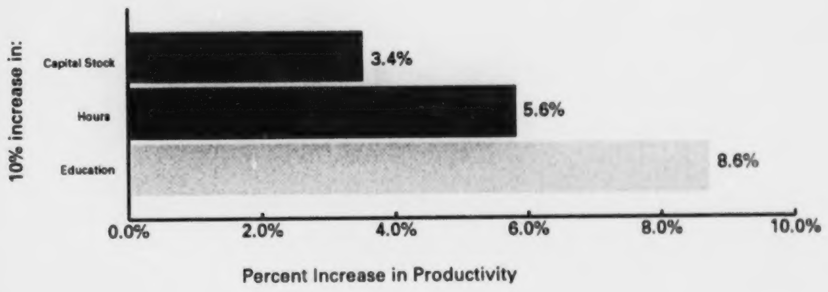
Other nations have been investing in the SET education and training of their citizens instead of sending them to U.S. universities, realizing the importance of developing their own human resources. Countries such as Taiwan and Korea have been aggressively encouraging their U.S.-trained citizens to return home by offering them prestigious positions and high salaries. Although many foreign SET doctoral recipients from U.S. universities plan to remain in the United States, the likelihood of this trend continuing is questionable at best.[14]

The nation's economic well-being, the health of its citizens, the defense of its interests at home and abroad—all these matters hinge on there being a reliable domestic pool of intellectual talent. If women, underrepresented minorities, and people with disabilities make up a majority and growing proportion of that talent pool, then it makes sense to take more effective action to nurture their intellectual development before turning to non-U.S. citizens for help.

Education Boosts the Bottom Line

A stronger investment in national talent through education and training boosts productivity more than any other means—more than increases in work hours or in capital stock. As shown in Figure 3, a 10 percent increase in capital stock or work hours can boost productivity 3.4 percent or 5.6 percent, respectively, while the same percentage of increase in education yields a productivity increase of 8.6 percent. As the data indicate, an increased investment in SET education will boost U.S. global competitiveness by increasing productivity.

Figure 3. Factors for Increased Productivity



Source: National Center on the Educational Quality of the Workforce, 1995

Bold Remedies for Tough Problems

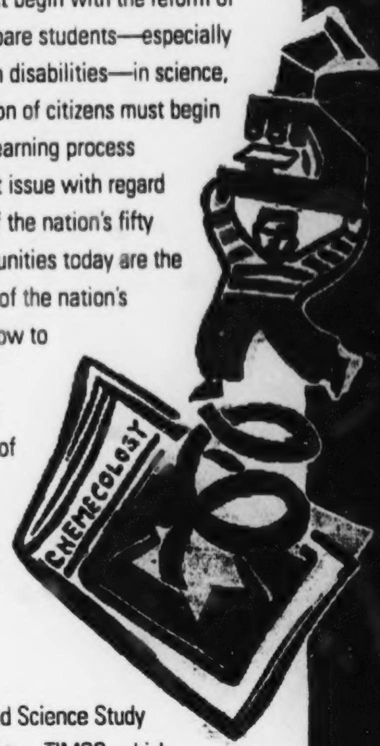
The goal of this report is to set forth recommendations that will support the building of a domestic SET workforce that achieves parity while meeting our nation's strategic SET needs. The recommendations of this Commission thus focus on issues of education and training that affect both how women, underrepresented minorities, and persons with disabilities move into SET careers and how their progress can be sustained during their tenure in the workplace. The Commission offers short-term solutions to stop the hemorrhaging of workers from the SET pipeline as well as long-term solutions to increase the supply of workers and establish parity between the SET workforce and the nation's general workforce population.

The Commision's recommendations, however, will be of little use without the joint efforts of the business community, federal and state governments, academe, and the nonprofit sector working in concert to craft bold remedies for tough problems. The actions required to carry out these recommendations call for a significant commitment of financial and other resources, as well as a system of accountability to ensure implementation.

PRECOLLEGE EDUCATION

"Twenty years from now we will look back at education as it is practiced in most schools today, and wonder that we could have tolerated anything so primitive."

John Gardner, Ph.D.
Professor, Stanford University
Former Deputy Secretary of Education



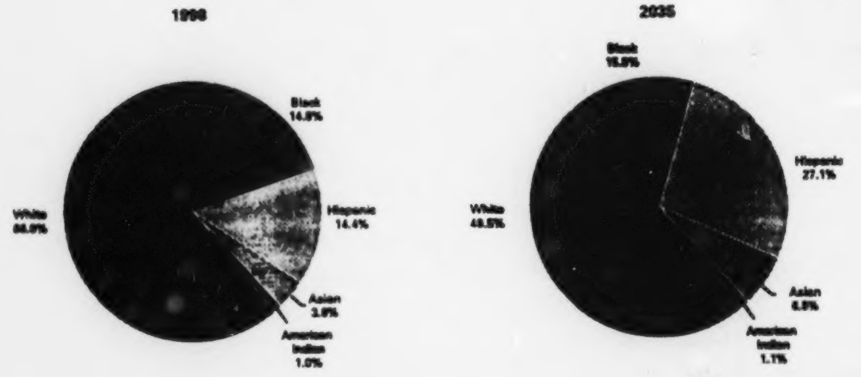
Efforts to increase the flow of skilled U.S. workers must begin with the reform of preK-12 education, which has failed to adequately prepare students—especially women, underrepresented minorities, and persons with disabilities—in science, mathematics, and technology. Attention to the education of citizens must begin as early as the preschool years (0-4 years), when the learning process begins. High-quality education is a particularly relevant issue with regard to minority children, who today constitute a majority of the nation's fifty largest school systems, and whose educational opportunities today are the most dismal. Currently, minorities make up 33 percent of the nation's school age population; by 2035 this percentage will grow to half of all school-aged children (see Figure 1).[1]

To understand the magnitude of the problem, it is useful to compare the mathematics and science skills of U.S. students to those of students in other countries, and then to consider the status of underrepresented groups in mathematics and science education relative to that of the white male population.

How Do We Measure Up?

The release of the Third International Mathematics and Science Study (TIMSS) in 1996 was a wake-up call for the United States. TIMSS, which compared curricula and achievement in 50 countries, ranked twelfth-grade U.S. students among the lowest performing students both in general knowledge of

Figure 1. Distribution of, and Projections for, 5- to 19-year-olds in the U.S. by Racial/Ethnic Group: 1998 and 2035



Source: 1998 data – U.S. Department of Commerce, 1999; 2035 projections – U.S. Department of Commerce, 1996.

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mathematics and science, and in more specific knowledge of physics and advanced mathematics.[2] Only five percent of U.S. twelfth graders who took Advanced Placement (AP) calculus performed as well as the top 10 to 20 percent of the same age group of advanced mathematics students in seven of sixteen countries. In physics, the outcome for U.S. students was somewhat worse, with U.S. students with AP physics scoring below the international average.[3]

At the eighth grade level the picture is somewhat rosier. Compared to five major economic partners—Japan, France, Canada, England, and Germany—U.S. students scored lower than Japanese students, not significantly different from English, Canadian, and German students, and higher than French students. U.S. eighth graders scored below average in mathematics achievement and above average in science achievement compared to the forty-one nations that participated in the eighth-grade level TIMSS assessment.[4]

U.S. fourth graders had the best showing of all U.S. students. They scored above average in both mathematics and science compared with the twenty-six nations in the TIMSS fourth-grade assessment. In fact, U.S. fourth graders were outperformed in science by only one country—Korea.[5] It seems, therefore, that as U.S. students progress through the education pipeline their performance in mathematics and science declines significantly.

Still a Long Way to Go

Despite the growing proportion of women in the workforce, the relative proportion of women in such fields as engineering, computer science, and physics lags far behind that of men.[6] Currently, only 19 percent of the SET workforce is female despite significant improvement among girls in mathematics and science achievement and course taking over the last 20 years. There are now only small differences between girls' and boys' science and mathematics scores on the National Assessment of Educational Progress (NAEP) tests,[7] and girls are now taking the upper level mathematics and science courses required to enter SET college majors at the same rate as boys.[8]

Although the ability and basic academic background needed to continue in SET careers exist for many girls, their interest in these careers is not maintained. Among SAT-takers, over three-fourths of students wishing to major in engineering and computer science are boys. The only science field attracting more girls than boys is the biological sciences.[9] By eighth grade, twice as many boys as girls (independent of race/ethnicity) show an interest in SET careers.

STEMming from Success

The nonprofit Center for the Advancement of Hispanics in Science and Engineering Education (CAHSEE) grew out of a series of meetings in the early 1990s among scientists and engineers concerned by the extremely low participation in SET careers by Latinos, especially women. At the time, most of the resources and efforts for Hispanic children were being directed to "high-risk" youth or academic underachievers, neglecting high-performing children who were also dropping out of the SET pipeline before they even reached college. CAHSEE was formed to change all that.

One of its most successful initiatives, launched in 1992, is the Science, Technology, Engineering and Mathematics (STEM) Institute. Minority students in grades 7-11 compete for admission to a six-week intensive program, where they are exposed to different aspects of mathematics, engineering, computer science, and engineering management, with an emphasis on intensive "minds-on" experience and critical thinking skills. Graduate and undergraduate Latino students teach some of the courses. Currently there are STEM Institutes in Washington, D.C. New York City, and Chicago, as well as in Santa Clara and Pasadena, California.

Another precollege program offered by CAHSEE called SAT/SOAR takes place during the school year and, over the course of eleven weeks, teaches students the verbal and mathematics skills necessary to obtain a high score on the SAT I and PSAT exams. The sessions are taught by Hispanic graduate students who act as both teachers and mentors to their students.

So far, more than five hundred students have participated in the STEM Institute and SAT/SOAR programs. Significantly, all STEM Institute students have continued on to college, mostly in science and engineering.

Also by eighth grade, girls' interest in mathematics and confidence in their mathematics abilities have eroded, even though they perform as well as boys in this subject.[10] Fewer girls than boys enroll in computer science classes, feel self-confident with computers, and use computers outside the classroom.[11]

So even while girls' achievement in SET increases, their interest and participation in science and mathematics activities go down. A combination of factors likely accounts for this paradox. Girls' rejection of mathematics and science interests may be partially driven by teachers, parents, and peers when they subtly, and not so subtly, steer girls away from the kind of informal technical pastimes (working on cars, fixing bicycles, changing hardware on the computer) and science activities (science fairs, science clubs) that too often are still thought of as the province of boys. Data show that girls are indeed less likely than boys to be involved in informal science and mathematics activities outside of school, from using meters and playing with electromagnets to fixing machines and reading about technology.[12] Additionally, media and real-life images of women in scientific and technical careers are still rare (as are female role models and mentors, in general), sending an unspoken message to girls that a SET career is not for them.

Adding Color to the SET Pipeline

In contrast to the underrepresentation of women in the SET workforce, the cause of underrepresentation of minorities in the SET workforce begins with lack of access to high-quality mathematics and science education during the K-12 years. A great many African American and Hispanic students attend schools in the central city (32 percent and 25 percent, respectively). Students in these groups also tend to be enrolled in predominantly minority schools. For example, in the fall of 1996, while the overall percentage of white students enrolled in public schools was 64 percent, only one-third or less of the students in a typical African American or Hispanic student's school were white.[13] This is important information, because it means that the majority of African American and Hispanic students are isolated in schools that typically suffer from a grievous lack of resources. Although much less data are available to document the access that American Indian

Students with Disabilities Get It Done

The University of Washington's Project DO-IT (Disabilities, Opportunities, Internetworking, and Technology) works to pull students with disabilities into the SET pipeline, and keep them there. Begun in 1992 with primary funding from the National Science Foundation, Project DO-IT connects adult SET mentors (many with disabilities themselves) and high school students through Internet communications tools, a live-in summer study program at the university, and other activities designed to motivate students with disabilities to consider a science or technology degree.

For example, the DO-IT Camper program hosts high school students with disabilities at summer camps, where they take special classes in how to use the Internet, how to prepare for college, and the exciting possibilities for them in a SET career. After camp, many of the kids become DO-IT Pals, who pursue their interest in SET through regular electronic communication and occasional visits with mentors and other students with disabilities from all over the world. DO-IT Pals undertake independent or team projects based on their interests, turning to mentors for help.

Elementary school children are exposed to the role models through the DO-IT Show and Tell program, which sends SET college students with disabilities into first-grade classrooms to talk about their interests and to demonstrate assistive technology, information access, and independent living skills. For example, Imke Durre, a doctoral student at the University of Washington, brings along her computer that talks. Because she's blind, Durre uses a refreshable Braille display with her speech output. She demonstrates how she uses a cane for mobility and brings along a child-size cane for the children to try. Exposure like this both encourages a child with disabilities to consider a future in science or technology and helps to change a culture in which only nondisabled persons are considered good candidates for SET careers.

The DO-IT program produces many teaching materials and techniques geared toward helping teachers actively engage students with disabilities in SET activities. The program has won numerous awards, including the 1997 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring.

students have to educational resources, these students also attend impoverished schools in which they are the racial majority. A recent *New York Times* article quoted the director of American Indian education at the Department of Education as saying, "We have schools that are literally falling down around the heads of Indian children."[14]

Data on the distribution of resources in schools ranging from expenditures, qualified teachers, high-quality curriculum, and computer equipment show that inner city, high poverty and high minority enrollment schools where African American and Hispanic students are concentrated consistently receive fewer resources than do schools that serve high percentages of white students. Although districts with the highest percentages of minority students have higher expenditures than those with the lowest percentages of minority students, when cost and student need adjustments are made, the relationship is reversed: districts with high percentages of minority students have lower expenditures because of lower buying power.[15]

High minority enrollment secondary schools also offer less extensive and less demanding science and mathematics programs, giving minority students fewer opportunities to take the courses necessary to help them pursue science and mathematics majors in college. Further, underrepresented minority students are disproportionately placed in lower track[i] courses and thus have less access to higher level courses, even when they are in schools that offer these courses. The negative effects of tracking are exacerbated in mathematics and science education because tracking affects not only the quality but also the quantity of courses that students may take. Over time, the effects of this practice compound and differences among tracks widen, as students who do not take prerequisite courses are excluded from more advanced classes.[16] Figure 3 (p. 20) shows the unequal access that high minority enrollment schools have to qualified mathematics and science teachers, and the section on "Equal Access to Technology" (p. 23) details the differential access of high-poverty schools to technological learning tools.

The shocking lack of educational resources experienced by underrepresented minority students affects both their achievement and participation in mathematics and science. Achievement and participation data tell us that it scarcely matters whether underrepresented students of color have an interest in SET careers. Because of the inadequate education received, low achievement levels often preclude their successfully attempting a SET career.

African American and Hispanic students perform well below white and Asian students in science and mathematics, and while the gap is closing, it is closing slowly. Over half of underrepresented students of color[ii] show less than "partial mastery" of science and mathematics at grades four, eight, and twelve as measured by NAEP, and while individual students of color possess superior mathematics skills, less than one-half of 1 percent of these students score at the advanced level of proficiency in mathematics on NAEP.[17]

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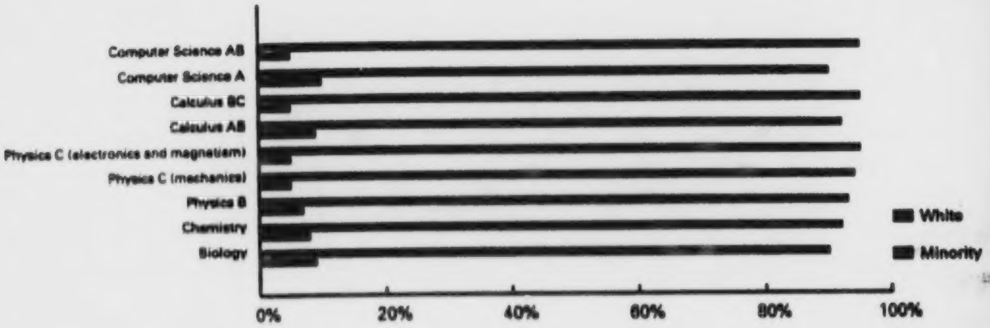
[i] Tracking is the practice of assigning, according to perceived ability level, groups of students to specific sets of courses (e.g., honors, vocational, academic).

[ii] This term refers to African American, Hispanic, and American Indian students who are underrepresented in SET careers.

Nationally, fewer African American, Hispanic, and American Indian students take advanced mathematics and science courses than do white and Asian American students (see Figure 2). And although underrepresented minority students are nearly 25 percent of the population, they are only 5 to 10 percent of AP test-takers in computer science, calculus, physics, chemistry, and biology.[18]

Students are not unaware of their poor preK-12 education. Nearly half of urban students taking the ACT express a strong need for assistance with their mathematics and study skills, and with making educational and career choices.[19] And although Hispanic and African American eighth graders have been found to express more positive attitudes about mathematics and to be more involved in mathematics/computer clubs than white students, their interest in SET careers is not as high.[20]

Figure 2. Advanced Placement Candidates, by Selected Subjects and Race/Ethnicity: 1996



Source: *Women, Minorities, and Persons with Disabilities In Science and Engineering:1998*, NSF, 1999.

In sum, better preparation and more role models are needed for underrepresented minority students to develop both the skills and interest they need to participate in SET careers.

Issues of Disability and SET Participation

Very little information is available on the achievement and participation patterns of students with disabilities in SET. The absence of NAEP data on this group deprives us of comparable achievement data at the fourth-, eighth-, and twelfth- grade levels. It is known, however, that students with disabilities who plan to attend college score significantly lower on the SAT and ACT than do other students. These students also take fewer high school mathematics and science courses than other students and receive lower grades.[21] Reasons for this lack of precollege preparation in mathematics and science vary, but include physical and attitudinal barriers. For example, it is often difficult for students with disabilities to access science equipment in middle and high school. In addition, as with girls, students with learning disabilities may be implicitly or explicitly discouraged from pursuing a SET education because of adult and peer perceptions of their abilities.[22]

The Educational System: Gatekeeper or Door to the Future?

> "Rather than weed out students and discourage them from science classes, we must encourage and inspire them."
>
> **Franca Cordova, Ph.D.**
> *Vice Chancellor for Research*
> *UC-Santa Barbara*

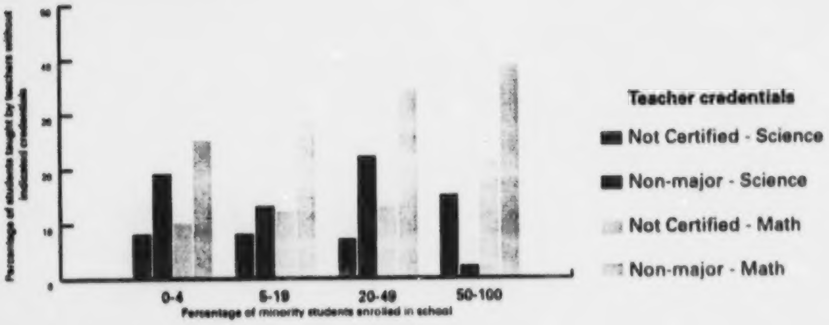
Free public education in the U.S., available as it is to all residents, can be a powerful mechanism to level the playing field for students from different socioeconomic levels and demographic characteristics. As it now exists, however, the educational system perpetuates inequality, as underrepresented minorities, women, and persons with disabilities have unequal access to educational resources. Report after report on the supply and quality of the workforce has called for the reform of the preK-12 education system as the most cost-effective way to increase the number of skilled adults in the future. Numerous efforts are currently underway at the local, state, and federal level to improve mathematics and science education. Improving teacher effectiveness, adopting national mathematics and science standards, and providing access to technology are critical to the reform efforts.

Further, it has only been in recent years that early childhood development has been recognized as the true beginning of learning and, therefore, the beginning of workforce development. The Commission encourages the continued focus and thrust in early childhood development and its long-term impacts on learning. The Commission acknowledges the impact that child care centers, for example, have on the early learning capabilities of children and also recognizes the opportunity that early childhood learning presents for the creation of our future workforce.

Teachers are Key

Teacher effectiveness has been identified as the most important element in the complex equation that makes up a good education. Boosting teacher effectiveness can do more to improve education than any other single factor. Recent studies show that effective teachers help students at all achievement levels, regardless of the level of heterogeneity in their classrooms. Additionally, standardized test scores suggest that teacher effects on student learning are additive and cumulative over grade levels.[23]

Figure 3. Public School Teachers of Mathematics and Science Without a Major or Certification in Class Subject: School Year 1993-94



Source: U.S. Department of Education, NCES, *The Condition of Education*, 1998.

Good teaching is imperiled by a growing shortage of qualified teachers. The inability of some school districts to find adequately prepared teachers has led to the widespread practice of granting provisional certification to individuals who have not been adequately prepared to teach. Furthermore, a large shortfall in the teacher supply is expected to materialize in the 2000s, resulting in a need for at least 2 million newly hired public school teachers by 2009.[24] This overall shortage will exacerbate the already critical shortage of mathematics and science teachers. Currently, because of this shortage, many who teach mathematics and science lack adequate preparation in these subject areas, a fact reflected by the TIMMS data. What's more, a large proportion of these poorly prepared teachers can be found in schools with large numbers of underrepresented minority students (Figure 3).[25] The implications of this situation are that underrepresented minority students are not getting the high-quality instruction they need to succeed in the pursuit of a SET education and career.

The National Commission on Mathematics and Science Teaching for the Twenty-First Century (the Glenn Commission) is addressing the issue of teacher quality and quantity in mathematics and science. The Glenn Commission is in the process of developing vitally important recommendations and corresponding action strategies to help ensure that sufficient highly skilled teachers enter and remain in mathematics and science teaching.

Mathematics and Science Standards for All

The emergence and widespread adoption of national standards in science and mathematics is an important development in K-12 education. The National Council of Teachers of Mathematics issued mathematics standards in 1989 (and revised them in 2000). In 1993, Project 2061's *Benchmarks for Science Literacy* by the American Association for the Advancement of Science was released, followed in 1996 by the National Research Council's National Science Standards.

These standards provide recommendations and guidelines for student learning, classroom practices, teacher professional development, and overall organization of educational systems.

American Indians Song of Honor

In one way, it's a typical summer residential camp for high school students. There are water fights on the hottest nights; fireside confessions of secrets, hopes, and dreams; a basketball game in which the students run the staff into the ground; and even a chance to build and erect a tipi. But in another way, the Scientific Knowledge for Indian Learning and Leadership (SKILL) program is more than just summer fun. By providing American Indian high school students with the support they need to succeed academically, SKILL is fighting back against drop-out rates for reservation school districts that are four times those of nontribal public schools.

In the eight years since the program's launch, nearly 90 percent of SKILL students are either still in high school or have graduated and gone on to college. The average high school GPA for SKILL participants is 3.6, and all have shown a marked gain in math skills.

The program is a collaboration of the South Dakota School of Mines and Technology (SDSM&T) and Oglala Lakota College, and is supported by NASA. American Indian high school students from South Dakota and nearby states are eligible. Students enter the program the summer prior to ninth grade, and return each year until they graduate from high school. The curriculum emphasizes hands-on learning of math, engineering, and the sciences, as well as computers, communication, and study skills. Follow-up activities during the school year include staff visits to reservation schools, support for science fair participation, and Web-based instructional materials. Both SDSM&T and Oglala Lakota College have been successful in recruiting girls—the summer camp typically hosts more female students than males.

The networking and support offered by the faculty and staff of SKILL are so effective that every year the students lobby SDSM&T administrators to make the program longer. Many students say it's the best time they have all year. At graduation, there are always a few tears from those who are going away to college.

"SKILL students earn the traditional honoring song presented at each year's graduation," notes SDSM&T's interim vice-president for student affairs, Francine Campone. "And they are powerful role models for the younger generations who follow them."

Many of the strategies advocated by both the national mathematics and science standards, such as hands-on activities and cooperative learning, have been found to stimulate interest and understanding of science and technology for all students, including girls, underrepresented minorities, and persons with disabilities. There has been, however, little assessment of how implementation of the standards—which varies widely from state to state—affects underrepresented populations. Enforcement of these standards should ensure that underrepresented groups have access to the high-quality education and resources that are often lacking in schools where underrepresented minorities tend to be enrolled. Inherent in the standards is the concept that all children can learn, given access to excellent and equal mathematics and science learning opportunities that develop not only basic skills but also problem solving and conceptual thinking. Such opportunities include access to quality teachers, appropriate learning materials, universal access for disabled students and other resources, and sufficient higher level mathematics and science courses. For these and other reasons, the standards are a crucial tool by which to lift underrepresented populations into the ranks of the twenty-first century SET workforce, and policymakers at the local level must be stimulated to embrace and implement them.

Helping Teachers Help Girls

Teachers are powerful instruments of change. At the nonprofit Washington Research Institute (WRI) in Seattle, staff members—professionals in the fields of education, psychology, social work, vocational education, and related areas—work to transform the way K-12 teachers-in-training learn how to encourage girls' persistence in science, mathematics, and technology. Starting in 1996, the agency began investing funds and staff resources in seven education colleges nationwide, helping them to form internal teams of faculty, administrators, students, and partner school principals and teachers. External mentors experienced in science, mathematics, and technology education as well as gender equity issues helped each team to assess the institution's need to improve or integrate material on gender bias in its teacher education program. Team leaders attended an initial seminar designed to foster their growth as effective advocates for change at their institution and all team members exchanged ideas through an electronic messaging list.

So far, the network has reached hundreds of student teachers and, through them, thousands of K-12 schoolchildren. By improving student teachers' gender equity skills before they reach the K-12 classroom, WRI is transforming the way girls and young women first experience science and technology and helping to create a culture that nurtures the full range of girls' dreams.

One way of ensuring equality of access to higher level mathematics and science courses is for schools to adopt a rigorous high school core curriculum where all students take the same, mostly academic courses. This practice, which was found to be a common characteristic distinguishing high-performing schools from others,[26] has been associated with higher achievement for students independent of race/ethnicity, gender, or income level.[27] A recent study found that a high school curriculum of high academic intensity and quality has a large positive impact on degree completion for students of all racial/ethnic groups, suggesting that African American and Hispanic students can succeed academically when provided with a high-quality education.[28]

For nearly a decade, the National Science Foundation has promoted and undertaken systemic reform at the K-12 level to stimulate comprehensive reform that entails teacher preparation and development, quality student preparation, rigorous mathematics and science curriculum and performance standards for all students, effective governance, and the alignment of financial investments. Systemic initiatives implemented at state, urban, and rural levels across the nation and at many sites have positively affected the educational infrastructure. Students have been directly affected, especially in terms of gains in state and local assessment results, increases in overall mathematics and science course taking, and increases in advanced mathematics and science course enrollment.[29]

The U.S. Department of Education, in partnership with other federal agencies and private industry, has recognized the need to develop specific strategies to overcome the SET gaps of students with disabilities. These strategies include designing multimedia curricula that are accessible, and that accommodate the varied physical and cognitive needs of children. In addition, the U.S. Office of Special Education has funded a number of programs to develop teaching approaches that will facilitate mathematics, science, engineering, and technology training for students with disabilities in grades K-12. The methods that emerge from these programs must be implemented nationwide if students with disabilities are to emerge from high school prepared to pursue further education and careers in SET.[30]

Equal Access to Technology

Education-related technology includes computers, calculators, and other tools that can enhance learning in mathematics and science. How many of our schools, however, are connected to the Internet or have enough computers to provide all students with exposure to the new technologies? The U.S. Department of Commerce has coined the phrase "the digital divide" to describe the dangerous split between those with access to new technologies and those without. Recent data on the digital divide show that under-represented minorities, low-income persons, less educated individuals, and children of single-parent households, particularly in rural areas or central cities, are among those most lacking in access to information resources.[31]

> "Every time a teacher defers to a boy for computer assistance ... we are telling our daughters that computers aren't for them. We're sowing seeds of doubt."
>
> **Roberta Furger**
> *Author*, Does Jane Compute? Preserving Our Daughters' Place in the Cyber Revolution

Having a computer in the home gives children a head start in using computers in the classroom while also supporting their after-school learning. Children's access to a computer at home has increased substantially in recent years.[32] By 1997 almost half of all students had a computer available at home. However, white children were significantly more likely to have a computer at home (61 percent) than were African American (24 percent) or Hispanic children (23 percent).

Family income also had a strong correlation with computer presence in the household. For example, just 20 percent of children from families with incomes under $25,000 had a computer, compared to 88 percent of those with family incomes above $75,000. Although boys were no more likely than girls to have a computer at home or to use it, 42 percent of girls used the household computer for word processing compared to 36 percent of boys, while 79 percent of girls played games on the home computer compared with 86 percent of boys.

Common computer applications appear to be linked to the differences in technology between boys and girls. The violent and aggressive games that boys frequently play on both home and school computers tend not to appeal to girls. It has been suggested that these games involve a small set of skills which boys seem to enjoy mastering by playing the games repeatedly, while girls seem to become bored with the repetitiveness. Unfortunately, the way computers are presented to many high school students is through these games.[33]

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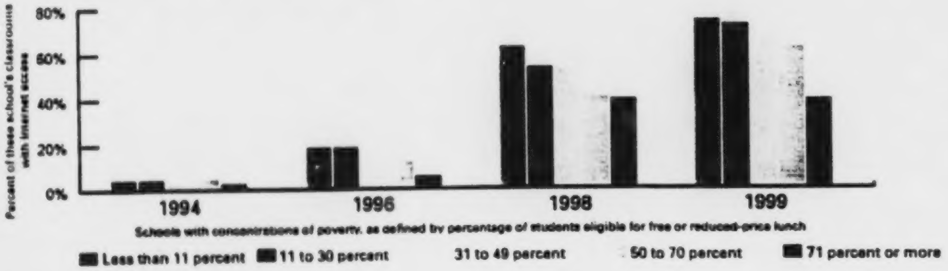
Figure 4. Percent of Public School Instructional Classrooms With Internet Access by Percent of Students Eligible for Free or Reduced-Price School Lunch: Selected Years 1994 to 1999



Source: *Internet Access in U.S. Public Schools and Classrooms: 1994-99* (NCES 2000-086).

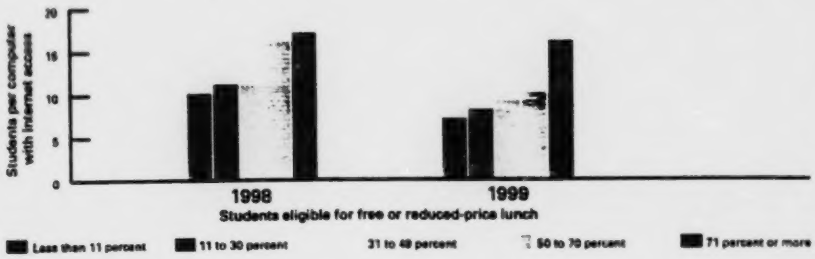
School is where most students, regardless of race/ethnicity, gender, or disability status can use computers. The percentage of schools connected to the Internet has increased from 35 percent in 1994 to 95 percent in 1999. And the percentage of U.S. public school instructional classrooms connected to the Internet rose dramatically from 3 percent in 1994 to 63 percent in 1999.[34] Despite this surge in Internet connections, disturbing differences remain in terms of Internet access in instructional classrooms. For example, in 1999, only 39 percent of instructional classrooms had Internet connections in schools with high concentrations of poverty (defined by 71 percent or more students being eligible for free or reduced-price lunch). In fact, no increases in Internet connections were recorded in these schools from 1998 to 1999, while there were increases in schools with lower concentrations of poverty (see Figure 4).

Data also show that schools with the highest concentration of poverty had more students per instructional computer with Internet access than schools with the lowest concentration of poverty (see Figure 5). Because schools with the highest concentrations of poverty are the ones most likely to educate low-income minority students, these students are being denied equal access to technological learning tools that are important for high-quality mathematics and science education and subsequent entry into a SET field.

The Precollege Challenge

Increasing the participation of women, underrepresented minorities, and persons with disabilities in SET fields must begin with adequate preschool education and continue through high school. It will require different strategies for each underrepresented group, but a common thread is the need for improvement in mathematics and science education for all of these students. Student interest in mathematics and science must be stimulated; strong curricula and high expectations must be the norm; committed teachers and technological tools must be provided; and students must be attracted to SET careers before they can enter into and persevere in the SET pipeline.

Figure 5. Ratio of Students per Instructional Computer with Internet Access in Public Schools, by Percent of Students Eligible for Free or Reduced-Price School Lunch: 1998-1999



Source: *Internet Access in U.S. Public Schools and Classrooms: 1994-99* (NCES 2000-086).

Because of the long-term nature of payoffs from systemic education reform, short-term solutions to the national shortage of SET workers must be implemented. Such solutions include programs that provide academic enrichment in mathematics and science to precollege students, as well as informal science programs that help students to see mathematics and science as interesting and fun. Intervention programs targeted at women, underrepresented minorities, and persons with disabilities in high school have been shown to quickly increase the number of students in SET college programs.[35] Given the programs' success in helping women, underrepresented minorities, and persons with disabilities to overcome the barriers to SET participation, it is time for these approaches to be institutionalized and made part of the mainstream so that all students can benefit from them.

The Commission supports precollege reform efforts now underway that focus on better preparation, added support, and professional development of teachers; that recognize the ability of all students to learn mathematics and science; that demand higher mathematics and science curriculum and performance standards for all students; and that promote for all students equal access to technology—both instructive and, in the case of students with disabilities, assistive.

Precollege Recommendation

The Commission recommends the adoption and implementation of comprehensive high-quality education standards, at the state level, concerning mathematics and science curricula, mathematics and science teacher qualifications (as recommended by the Glenn Commission), technological assets, built environments, assistive technologies, and physical infrastructure.

➢ The National Commission on Mathematics and Science Teaching for the Twenty-First Century (the Glenn Commission) is addressing issues related to the national shortage of qualified mathematics and science teachers, and is creating action strategies to improve the quality of teaching in mathematics and science at all grade levels nationwide, and to ensure that an adequate supply of highly skilled mathematics and science educators enter and remain in teaching.

- The Commission recommends that all states adopt and enact legislation requiring school districts to collect achievement data on students disaggregated by socioeconomic status, limited English proficiency, disability status, race/ethnicity, and sex, and should hold districts, school boards, and schools accountable for the success of all subgroups in meeting state achievement standards.

ACCESS TO HIGHER EDUCATION

"If students were fearless in math when entering college, the science courses wouldn't be so difficult and unattractive. It cannot be stressed enough that proper…course preparation in mathematics and science [is] crucial."

Mariana Loya
Engineering Student, University of Washington

More than ever before, the ticket to a skilled job and economic well-being is higher education. An Educational Testing Service study estimates that 86 percent of high-tech jobs require at least some college education.[1] Jobs that require an associate's degree or higher are projected to grow faster than the average for all occupations. Bachelor's degree proficiency will grow almost twice as fast as the overall average, and the three fastest growing occupations—all computer-related—require at least a bachelor's degree.[2]

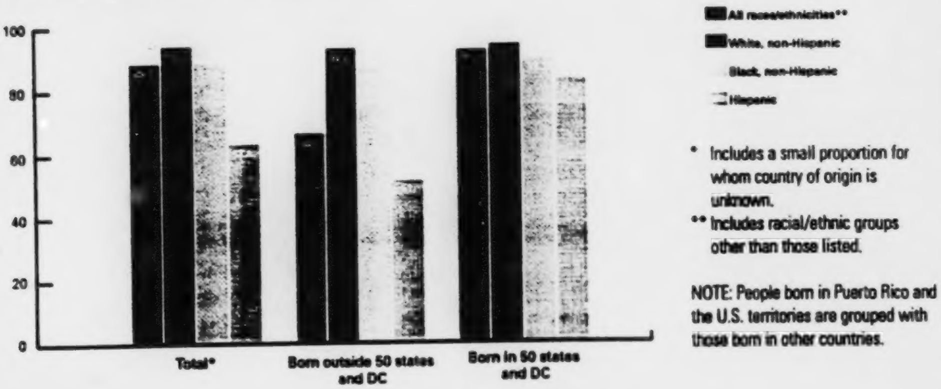
This news comes at a time when enrollments in many science and engineering majors are declining among U.S. students. In 1997, U.S. universities awarded just 44 percent of doctorates in engineering and 52 percent of doctorates in physics to U.S. citizens. This is the first year since 1980 that the number of science and engineering doctorates had declined.[3] Equally disappointing, in comparing the first *Women, Minorities, and Persons with Disabilities in Science and Engineering* report of 1982 with the latest edition for the year 2000, it is noticeable that at least one finding has not changed: the relatively small percentages of these groups that are earning science and engineering degrees.

Examination of the SET pipeline includes high school completion rates of women, underrepresented minorities, and persons with disabilities and the progress of these groups through higher education ending with the Ph.D.

High School Completion

Women and men have similar graduation rates, with women being slightly more likely to graduate from high school than their male counterparts (90 percent of women versus 87 percent of men). On the other hand, Hispanics, African Americans, and American Indians have lower high school graduation rates than whites (see Figure 1) but have shown marked increases over the past 30 years. In 1971, only 59 percent of these minority groups had completed high school, as compared to 82 percent for whites. By 1998, 88 percent of African Americans had achieved their secondary school degrees, compared to 94 percent of whites. While still not on par with whites, African Americans have made strides in high school that warrant continued and expanded support.

Figure 1. Percentage of 25 to 29 Year Olds With a High School Diploma or Higher, by Race/Ethnicity and Nativity: March 1998



* Includes a small proportion for whom country of origin is unknown.

** Includes racial/ethnic groups other than those listed.

NOTE: People born in Puerto Rico and the U.S. territories are grouped with those born in other countries.

Source: U.S. Department of Commerce, U.S. Census Bureau, March Current Population Survey, 1998.

The most recent data (1990) show that the high school graduation rate of American Indians (66 percent) is significantly lower than that of whites (78 percent). More recent data are needed to determine whether American Indian students are still lagging behind other groups in finishing high school, but anecdotal evidence is not encouraging. Students with disabilities are another group struggling to improve graduation rates. In 1994, 72 percent of students with disabilities versus 84 percent of students without disabilities received a high school diploma.

At 63 percent in 1998, Hispanics have the lowest high school completion rates among these groups, showing little change since 1982. Some of this can be attributed to the large number of foreign-born Hispanics in this age range who entered the U.S. without a high school diploma. Excluding the foreign born, high school graduation rates for U.S.-born Hispanics increases to 83 percent, a better rate but still lower than the 94 percent graduation rates for whites. There is little consensus on the reasons for the relatively low rate of high school completion among Hispanics overall, but some researchers point to the value often placed in Hispanic communities on young adults' contribution to the family finances, as well as language barriers that discourage success in school. These data highlight the need for programs that specifically target Hispanic youth.

Intention to Major in SET

Among those students who graduate from high school and enroll in college, how many express an interest in pursuing a SET degree? In a 1998 survey of first-year students in four-year colleges and universities, one-third of white, African American, Hispanic, and American Indian students, and 43 percent of Asian students, had intentions of majoring in science and engineering.[4]

Students with disabilities are as likely as students without disabilities to intend science and engineering majors. One study found that 30 percent of students with disabilities expressed an interest in a SET major, and while they were underrepresented in life sciences, physical sciences, and math, these

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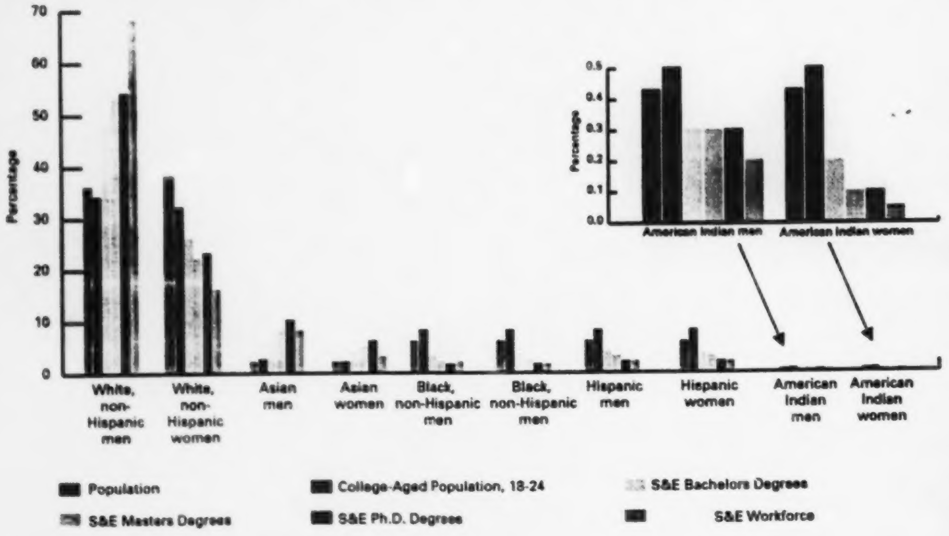
students enrolled in slightly higher percentages than those without disabilities in computer/information science and engineering majors.[5] These data show that there is at least a similar level of interest in SET fields among first-year students as a whole—except when it comes to gender.

No matter what their race, ethnicity, or physical ability, women are significantly less likely than men to intend a SET major. This means that right at the start of their college careers, women with or without disabilities and from all different racial/ethnic groups are opting out of the education they need to succeed as scientists or engineers.

Who's Left in the SET Pipeline? College Degree Completion

Figure 2 illustrates the data on bachelor's and graduate SET degrees relative to the population as a whole, the college age population, and the workforce. The data illustrate that white women, American Indians, and especially African Americans and Hispanics of both sexes are underrepresented as science and engineering degree recipients at all levels, given their representation in the college-age population. On the other hand, the proportion of white males and Asians earning SET degrees and working in these fields is greater than their proportion of the college-age population, especially for Asian males. (References to science and engineering [S&E] degree attainment in subsequent sections will correspond to Figure 2.)

Figure 2. Percentage of Population, College-Age Population, S&E Bachelor's Degrees Awarded, S&E Masters Degrees Awarded, S&E Ph.D. Degrees Awarded, S&E Workforce, 1997*



*Figures for doctoral degrees only are for 1998.

Source: Population Estimates Program, Population Division, U.S. Census Bureau.

Tabulations by National Science Foundation/Science Resources Studies; Data from Department of Education, National Center for Education Statistics, Integrated Postsecondary Data System, Completions Survey, and Survey of Earned Doctorates.

Bachelor's Degree Completion in Science and Engineering

Overall, about one-third of all bachelor's degrees are earned in science and engineering fields. At 37 percent in 1997, women earned a little over one-third of all science and engineering bachelor's degrees. While still below parity, this figure reflects a trend in which women have been earning an increasing percentage of such degrees. Exceptions of concern are engineering, computer science, and physics. After reaching a high of 37 percent in 1984 in computer science, the number of women in this important field dropped to 27 percent in 1997.[6] Women have traditionally been underrepresented in engineering and physics, and the growth in number of bachelor's degrees in these fields has been very slow. In 1985, women earned 15 percent of the bachelor's degrees in engineering; by 1996, this number had increased to only 18 percent. Similarly, women earned 14 percent of the bachelor's degrees in physics in 1985, and that number increased to only 18 percent by 1996. The growth in these fields has been almost stagnant.[7] True parity would raise the proportion of SET degrees earned by women to half.

While women of all backgrounds earn fewer SET bachelor's degrees than men, there are differences among women in terms of race and ethnicity. In 1997, African American, Hispanic, and American Indian women were much more severely underrepresented than white women compared to their presence in the college-age population; Asian women were overrepresented.

Although women in general are less likely than their male counterparts to enroll in college with the intention of studying a science-related field, those who do settle on SET are more likely than men to have graduated within five years. Of students who entered a bachelor's degree program in 1987, 76 percent of women and 70 percent of men had earned a bachelor's degree by 1992.

Lack of financial and academic support influences the completion rates of all students, particularly underrepresented minority students, who on average face a more severe financial burden in paying for college. According to the U.S. Department of Education's *Baccalaureate and Beyond* study, SET graduation rates differed within racial/ethnic groups, as well as by sex.

An Entry Point for Students with Disabilities

How can employers who are open to the idea of hiring SET workers with disabilities find potential candidates? One way is through the American Association for the Advancement of Science (AAAS) program, ENTRY POINT!

AAAS acts as the broker between undergraduate and graduate SET students with disabilities and prospective employers, chiefly the program's top partners, NASA and IBM. Drawing on strong connections to campuses and disability-related services, AAAS conducts a nationwide search for talented students with disabilities who are majoring in technical fields. Selected students embark on summer internships featuring mentors, assistive technology, and other necessary accommodations provided by the employer. Students receive exceptional support toward establishing a SET career; employers get access to a talented pool of potential employees.

In 1999, there were fifty-four students in the ENTRY POINT! program, up from six in 1996. A significant number of underrepresented minority students have participated in the program, including Toya Barros. Barros, who is hearing impaired, studied physics and aerospace engineering at Spelman College in Atlanta, Georgia, before moving on to Georgia Tech. She interned at the NASA Langley Research Center in Hampton, Virginia. Another participant has been Tim Scamporinno, who studied computer science at Sonoma State University in California. Formerly an intern at IBM in San Jose, Scamporinno, a wheelchair rider, now works full time at IBM.

"ENTRY POINT! has given me the opportunity to demonstrate my technical knowledge in a very challenging position at IBM," says Scamporinno. "As a result, my talents have been recognized, not overshadowed by my disability, as has been the case when I attempted to seek employment on my own."

The program, he says, allowed him to "rise above the discrimination and close the gap between being a student and becoming a professional."

- Among women, graduation rates were fairly similar, with white women, at 78 percent, having the highest rates as compared with their African American (71 percent), Asian (70 percent), and Hispanic (68 percent) counterparts.
- Among men, African Americans and Hispanics were far less likely than white males to graduate from college within five years. Of all male students entering a bachelor's degree program in 1987, 71 percent of white students, 79 percent of Asian students, 51 percent of African American students, and 52 percent of Hispanic students earned their degree by 1992.
- Small sample sizes do not permit reporting of data on American Indians.[8]

Another study conducted by The National Action Council for Minorities in Engineering (NACME) focused on the graduation rates of engineering students by race/ethnicity. The study found that 37 percent of underrepresented minority first-year engineering students were retained through graduation, while 68.3 percent of their nonminority counterparts graduated. Disaggregating the data further, it was found that African American and American Indian engineering students had much lower graduation rates (32 percent and 34 percent, respectively) than did Hispanics (45 percent).[9]

The most common barriers to completion faced by students with disabilities are the faculty's negative predisposition to students' accommodation needs; conflicting policies between the financial and educational systems; and actual disability limitations.[10] These barriers contribute to students with disabilities being less likely than those without to be enrolled in or to have completed a SET bachelor's degree within five years (53 percent versus 64 percent).

Higher Attrition Rates for Underrepresented Groups

Not only are women and underrepresented minorities less likely than white men and Asians to major in a SET field, but once there, they are more likely to switch to nonscience majors. A greater proportion of women switch out of SET majors than men relative to their representation in the SET major population.[11] Reasons cited for this higher proportional attrition rate among women SET students include: more interest in a non-SET major; poor quality of SET teaching; an inflexible curriculum; lack of role models; stereotyping of science and engineering as "male" fields; experiences of gender bias; distaste for the competitive nature of science and engineering education; psychological alienation; an inability to obtain adequate academic guidance or advice; and low faculty expectations.[12]

African American and Hispanic students are more likely than white and Asian students to drop out of college entirely. Reasons for these higher attrition rates —especially for students in SET—include financial difficulties, poor precollege preparation, low expectations from faculty, poor quality of teaching, and an inflexible curriculum.[13]

Declining Enrollment Among Underrepresented Minorities in Engineering

Recent declines in engineering enrollment among underrepresented minority students, which exceed a similar decline among nonminority students, are particularly disturbing. The number of underrepresented minorities enrolled as full-time first-year students in engineering declined by 5 percent overall from 1992 to 1996. The loss among Hispanics was relatively light though still disturbing (a 3 percent drop between 1991 and 1996),[14] but African American enrollment fell by 16 percent. Although recent data from the Engineering Workforce Commission is more encouraging—African American engineering enrollment jumped by more than 8 percent between 1997 and 1998—it is not clear whether the overall downward trend has been reversed, as 1998 first-year student enrollment was still considerably lower than it was in 1992.

The declines do not seem to be associated with changes in college participation rates, smaller numbers of qualified high school graduates, decreases in the numbers of 18-year-olds, or any other demographic shifts. Instead, they may reflect a shift in the values, interests, and career choices of students.[15] Given the growing need for skilled engineers, however, reasons for the decline should be vigorously explored and countered.

Assessment Alternative Yields Strong Minority Engineering Students

In the mid 1990s, as the anti-affirmative action movement pushed universities to rely increasingly on one-dimensional measures of academic potential, such as SATs, the National Action Council for Minorities in Engineering (NACME) developed the Engineering Vanguard Program. Recognizing that many extraordinary students from inner city schools and educationally disadvantaged backgrounds are deprived of the opportunity to develop skills measured by these one-dimensional gauges, NACME established more authentic criteria for selecting students for the program.

NACME assesses content knowledge, mathematics problem-solving behaviors, and critical-thinking skills by engaging students in a comprehensive, performance-based process. Students are taught new concepts and invited to solve complex problems, working in collaborative teams. Participating students are evaluated on their ideas, creativity, and approaches to solving unfamiliar problems, exactly the competencies that make for successful engineers.

Through this highly interactive assessment, along with in-depth individual interviews, NACME assembles cohorts of Vanguard scholars who might otherwise be inadmissible to participating universities. To bridge the gap between the courses available in inner city schools and the preparation that students are presumed to have on matriculation at an engineering institution, all Vanguard students participate in rigorous, intensely focused academic workshops during their senior year in high school. By the program's end, students coalesce into high-functioning, academic teams. And as teams, Vanguard scholars enroll in engineering schools that have prior agreements with NACME to use Vanguard assessment in the admissions process.

Selected Vanguard scholars are offered full tuition and housing scholarships to one of 10 participating universities with engineering programs, including Drexel University, Rensselaer Polytechnic Institute, and Texas A&M University. Currently, NACME runs the program at high schools in underserved communities in metropolitan New York, northern New Jersey, Houston, Philadelphia, and Rochester. Plans are to expand the program to Alaska, California, Colorado, and Rhode Island by the end of 2000.

Participating institutions benefit from the rapid infusion of a richly diverse group of students who are uniquely and rigorously prepared to succeed. Although nationally, fewer than 36 percent of the minority freshmen who enter engineering programs graduate with an engineering degree, student persistence over the six years that Vanguard has been in existence stands at 98 percent. What's more, their combined GPAs average 3.0, with about one-quarter of the students achieving a GPA above 3.5.

In posting such results, NACME has exploded traditional assumptions about student potential and developed tools that are much more effective than standardized tests and grades in predicting achievement for students from widely varying backgrounds. Equally important, through Vanguard, NACME has introduced accelerated techniques that quickly develop academic competency, allowing students from nontraditional educational experiences to excel in the engineering environment.

The Role of Two-Year Colleges

Approximately 44 percent of all U.S. undergraduates enroll in two-year colleges. This enrollment contains a large percentage of underrepresented groups:

- Women were 57 percent of the total enrollment in 1996, the same level as in 1990;
- Over half—54 percent and 52 percent, respectively—of Hispanic and American Indian undergraduates are enrolled in two-year colleges (1996); and
- Forty-six percent of African Americans, 45 percent of Asians, and 42 percent of whites in higher education are enrolled in these institutions.

Although relatively few students complete their associate's degrees and even fewer seek degrees in science and engineering from the two-year colleges (the two most popular fields being computer science and engineering technology), many students transfer to four-year colleges.

Given the large numbers of U.S. students—many of them women, underrepresented minorities, and persons with disabilities—whose first attempt at a postsecondary education is a more accessible two-year college, these colleges can provide the foundation for college degrees and entry into the nation's skilled workforce. Policies that eliminate barriers for potential SET majors to transfer to four-year institutions could be especially fruitful, both for short- and long-term needs. Twenty-six percent of all students at two-year colleges, regardless of major, who begin their undergraduate careers in a two-year college transfer to four-year institutions. These transfer students complete their bachelor's degrees at a rate of more than 70 percent.[18] Of persons who earned science and engineering bachelor's degrees in 1995 and 1996, 14 percent of women and 13 percent of men had earned associate's degrees. For minorities, these figures were: 12 percent of Asians, 11 percent of African Americans, 15 percent of Hispanics, and 20 percent of American Indians. Twenty-three percent of disabled science and engineering bachelor's degree recipients had associate degrees as compared to 13 percent of those without disabilities.

The Role of Minority-Serving Institutions (MSIs)

Minority-serving institutions (MSIs) also play an important role in nurturing the talent of underrepresented minority students. Although the vast majority of these students now attend predominantly white institutions of higher education (PWIs), MSIs provide models of successful approaches of educating underrepresented minority students.

Community Colleges Rise to the Challenge

Among the many programs cited by the American Association of Community Colleges (AACC) as working to open SET doors to women, underrepresented minorities, and persons with disabilities is the Advanced Technology Education (ATE) program, funded by the National Science Foundation. Working primarily through two-year colleges, ATE projects provide students and faculty with stronger technical curricula geared toward high-technology fields. For example, an ATE project at Northwest Indian College has enrolled 23 American Indians, eight of them women, in an environmental and natural resource management degree program.

Community colleges also partner with corporate America. Through the AACC's Working Connections Project, Microsoft provided a $7 million grant, in addition to $18.5 million in software, to increase the number of underrepresented students in information technology careers. And in SPRINT's hometown of Kansas City, Missouri, the Metropolitan Community Colleges and local agencies collaborate with the telecommunications giant to provide scholarships, tutoring, and other support to ethnic minorities in engineering. "Bringing these underrepresented individuals into the emerging mainstream of 'smart' jobs is not only a matter of equity," observes David R. Pierce, AACC's president and CEO. It is also crucial to avoid the schism in our society that lack of access and technical skills will inevitably mean in a Knowledge Age."

For example, Historically Black Colleges and Universities (HBCUs) have played a significant role in the production of African American science and engineering degree recipients. Of African Americans earning bachelor's degrees in SET fields in 1996, 31 percent received them at HBCUs. Furthermore, a high percentage of African Americans who go on to earn advanced degrees in science fields received their baccalaureate degrees at HBCUs.[17] Of African Americans earning doctorates in the sciences between 1975 and 1992, more than half of the biologists, slightly less than half of the physical scientists, and more than two-fifths of the mathematicians and computer scientists had baccalaureate origins in HBCUs.[18]

Hispanic-serving institutions (HSIs) and tribal colleges and universities (TCUs), though important educational institutions for Hispanic and American Indian students, respectively, do not serve as large sources for SET bachelors degrees. HSIs and TCUs are located in regions where the groups they serve are most concentrated. For Hispanics, these are California, Texas, and Puerto Rico. Many Hispanic Americans enroll in HSIs, yet only 69 out of the 220 existing HSIs have engineering programs (45 out of 175 two-year institutions and 24 out of 49 four-year institutions).[19] This situation leaves many Hispanics without the option of pursuing an engineering education.

Similarly, SET educational programs are lacking at many TCUs. California, Oklahoma, and Colorado are home to most tribal colleges. HSIs provided 20 percent of all SET bachelors degrees awarded to Hispanics in 1996; for American Indians, TCUs awarded only 1 percent. While it is imperative that federal and state governments invest in the development and strengthening of SET programs at HSIs and TCUs, continued investment is also essential to those predominately white institutions (PWIs) that currently produce the largest numbers of underrepresented minorities with undergraduate SET degrees.

Pioneering Women in Engineering

Launched in 1969, Purdue University's Women in Engineering Program was the first of its kind in the United States. During the program's first ten years, the number of women enrolled in the Schools of Engineering jumped from forty-three (less than 1 percent of the total) to 995 (15 percent). Today 22 percent of engineering students at Purdue are women and they comprise 25 percent of all undergraduate engineering degrees earned at the university, compared to 18 percent nationally.

What is the secret to Purdue's success? Its multifaceted approach includes campus climate workshops, which use interactive theater as a way to engage teaching assistants and faculty in learning to create a productive classroom climate for a diverse range of students; mentoring programs that match women further along in their engineering education with women further back in the pipeline; and the establishment of on- and off-campus living units for undergraduate women pursuing an engineering degree.

These and other retention efforts provide motivational career information, use role models to dispel negative stereotypes, offer hands-on experiences with computer and other devices (the kind of tinkering that girls tend to be discouraged from); create opportunities for women students to interact socially and educationally; and involve women students in program development. The result: more young women have earned engineering degrees from Purdue University than from any other college or university in the country.

Graduate School: A Mixed Report

Graduate School Enrollment

Although overall graduate enrollments increased nearly 4 percent from 1992 to 1996, the number of graduate students in SET degree programs has been declining steadily—about 2 percent from 1996 to 1997, the fourth consecutive year in which a decline occurred. This is an alarming development given that a nation's economic advantage comes more and more from technical innovations and the competitive application of knowledge.20

When taking a closer look at this picture with regard to women, underrepresented minorities, and persons with disabilities, it is important to distinguish between relative values and trends. While some trends may be encouraging, the relative numbers of underrepresented persons in SET graduate programs remains disappointing. For example, the percentage of women among graduate SET students has increased slightly in recent years while male enrollment has declined after a peak in 1992. But in 1997, women constituted only about 39 percent of the students in graduate SET programs—still far short of parity.

The numbers of African American, Hispanic, American Indian, and Asian graduate students have increased since 1982. Although white SET graduate enrollment numbers increased overall between 1982 and 1997, they suffered a drop between 1993 and 1997. Once again, while the trend for underrepresented minorities in SET graduate program is positive, their numbers relative to whites are still disappointing.

Data on trends in graduate enrollment of students with disabilities are not available. We do know, however, that college graduates with disabilities are equally as likely as those without disabilities to enroll in graduate school within a year after graduating from college.[21] Information from the 1996 National Postsecondary Student Aid Study reveals that about 3 percent of graduate students studying in all fields reported a disability. Lower percentages of graduate students with disabilities than of those without were in life and physical sciences, engineering, computer sciences, and mathematics in 1996.[22]

Graduate Degree Attainment

Factors that influence graduate degree attainment are many and may be somewhat similar for different underrepresented groups in SET. There are factors, however, that are specific to individual groups. Women's retention and graduation in SET graduate programs are affected by their interaction with faculty, integration into the department (versus isolation), attitudes regarding marriage and child-bearing, demands of family, the nature of the discipline, lack of role models and mentors, and lack of female faculty.[23] Factors that affect the persistence and completion of underrepresented minority graduate students in SET are similar to those that affect women, with additional factors being the greater need for financial assistance, lack of peer support, and lack of minority faculty.[24] The completion rates of students with disabilities in SET are particularly affected by a lack of access to individualized assistive technology, modification of programs and materials, and personal assistance.

The number and percentage of women earning master's degrees in science and engineering fields have risen steadily since 1966, while men's degrees in these fields showed little increase. The overall increase for women, however, masks some hard facts:

- The 31 percent of SET master's degrees granted to women who were U.S. citizens and permanent residents in 1997 represents a smaller percentage than the same group earned of bachelor's degrees (37 percent) in these fields;
- There is variation in the distribution of master's degrees to women among fields within science and engineering. For example, women earn the highest percentage of SET master's degrees in the life sciences (37 percent) and the lowest in engineering (19 percent); and

- Both the numbers and percentages of master's degrees to women in mathematics and computer science have remained relatively stagnant since the late 1980s (see the following "Special Issues" section).

In terms of doctoral degrees in SET, both the number and percentage of women earning these degrees have risen steadily since 1966. Yet in 1998, women still earned less than one-third of all science and engineering doctoral degrees.

Turning to underrepresented minorities, the number and percentages of master's degrees in science and engineering granted to all racial/ethnic groups increased in the 1990s. These increases occurred in most major science and engineering fields, except for computer science and physical sciences. Of all doctorates earned in SET by U.S. citizens and permanent residents in 1998:

- African Americans earned 304 (2.5 percent);
- Hispanics 425 (3.5 percent);
- American Indians 53 (less than 1 percent);
- Asians 1,804 (15 percent); and
- Whites 9,100 (75.5 percent).

Clearly there is work to do in this area, despite the fact that the number of doctoral degrees granted to minority students increased between 1975 and 1998.

No data are available for master's degrees granted to persons with disabilities. This group, however, earned about 4 percent of the total science and engineering doctoral degrees awarded in 1998. Disabled SET doctoral recipients increased 78 percent (from 200 to 355) from 1989 to 1995.[25]

There are few efforts that directly target the retention of underrepresented minority, women, and disabled graduate students in SET. The programs that do exist usually focus on recruitment and/or financial support rather than interactive support programs. For students with physical disabilities, there is rarely a specific program focused on removing barriers; the disabled student services (DSS) office is the primary source of assistance. Furthermore, students with physical disabilities who major in SET may find that the DSS at their institution may not have encountered their specific needs before, especially in lab courses or when specific technologies or services are required.[26]

Special Issues

Adequate Preparation in High School

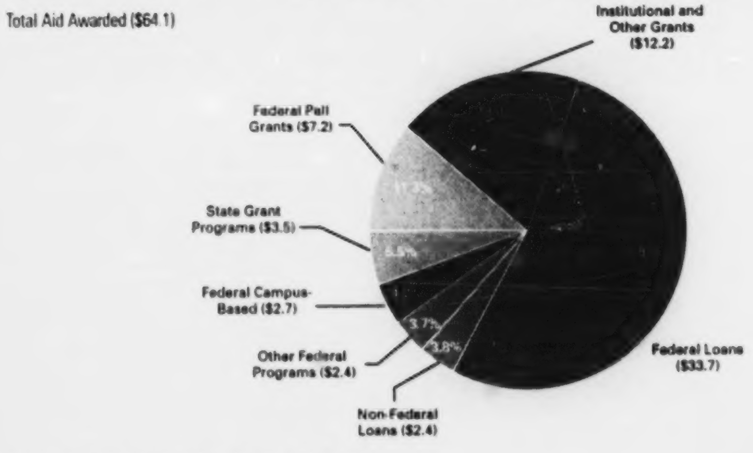
A high-quality academic curriculum in high school has a pronounced impact on bachelor's degree completion of all groups of students. In fact, a recent study showed that the highest level of mathematics studied in high school had the strongest continuing influence on undergraduate degree completion for all students, regardless of race/ethnicity, thus demonstrating that underrepresented minority students can succeed, given high-quality preparation in high school.[27] However, as has been discussed, various socioeconomic factors limit access to higher level science and mathematics courses in high school. With poor preparation, their lower levels of persistence in college are not surprising.

Financial Aid

The availability of financial aid at both the undergraduate and graduate levels has been tied to all students' decisions to enroll in postsecondary education, choose a specific major, and complete a degree.[28] As one might imagine, students are more likely to enroll in and complete college if financial aid is available to them. The availability of financial aid is especially critical for underrepresented minority students, who as a demographic group tend to have lower incomes than the body of white students. A study by NACME revealed that meeting the financial need of underrepresented minority engineering students is a key factor in addressing the problem of attrition.[29] A study by the U.S. General Accounting Office (GAO) came up with a similar conclusion for students from low-income families.[30] Another GAO study showed that providing students with scholarship aid (as opposed to loans, which must be paid back) has a dramatic impact on the retention of low-income students. Among students from the poorest families, a shift of just $1,000 worth of assistance from scholarship aid to a loan reduces the probability of graduation by 17 percent.[31]

How much and what kind of financial aid is available to students, especially women, underrepresented minorities, and disabled students? The most important change in federal student aid policy occurred twenty-five years ago and involved a drastic shift from a grants-based to a loan-based system (see Figure 3). In the last ten years, loan aid more than doubled compared to a two-thirds increase in grant aid.[32] During this period total aid increased approximately 85 percent in constant dollars, but the growing reliance on loan programs was responsible for two-thirds of the increase.

Figure 3. Estimated Student Aid by Source for Academic Year 1998-99 (Current Dollars in Billions)



Source: *Trends in Student Aid*, the College Board, 1999.

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Although recent increases in the Pell Grant appropriations have helped to stabilize the loan-grant balance in the aid system, the maximum Pell ($3,000 per student in 1998-1999) remains far below the purchasing power it had ten years ago. It manages to cover slightly over one-third of the average yearly cost of attendance at a four-year public institution and one-seventh that of a private institution. Tuition increases have far outpaced the growth in personal and family income during the 1980s and 1990s, with the share of family income required to pay college costs rising the most for those at the bottom of the economic ladder.[33] A study by the National Bureau of Economic Research found that a $1,000 increase in public two-year tuition led to a 6 percent drop in undergraduate enrollment, with the effect concentrated among low-income youth.[34]

> "One of the critical issues of the post-Cold War era [is] how to...harvest the creative potential inherent in a diverse workforce."
>
> **George Campbell, Jr., Ph.D.**
> *President, The Cooper Union for the Advancement of Science and Art*

One of the most notable trends in student financial aid during the 1990s was the increase in the dollar volume of federal student loans, which doubled from $13 billion in 1989-90 to about $28 billion in 1995-96 and has been estimated to be about $34 billion in 1997-98.[35] In FY 1999, an estimated 8.2 million students received federal student financial aid. The percentage of undergraduates receiving federal aid in 1995-96 was about 35 percent, with a little over 20 percent receiving grants and 25 percent receiving loans. During this period, 15 percent of undergraduates also received institutional aid and 11 percent received state funds, for a total of 50 percent of undergraduates who received any type of financial assistance.[36]

Obviously, the rising costs of college tuition and the small amount of grant funding available to students reduces the feasibility of a college education for low-income students, many of whom are from minority backgrounds. This lack of affordability may be exacerbated for students in science-based programs where the time demands of coursework make employment during the academic year a hardship.

At the graduate level, students are eligible for several different types of financial assistance from a range of sources: the federal government, the state, the institution, and private foundations. Types of financial support include fellowships, loans, teaching assistantships, and research assistantships. Until recently, underrepresented minority students were more likely to hold fellowships than white and Asian students.[37] This may have changed within the past few years because of challenges to race-based fellowships. Funders of large fellowship programs for underrepresented minority students such as the National Science Foundation, the Department of Education, and the Ford, Danforth, Mellon, and McKnight Foundations have either suspended these programs or are re-examining which mechanisms are most effective in providing support. Several institution-based fellowships have been discontinued, such as the University of Texas at Austin's Minority Graduate Fellowship Program, a major source of funding for minority students at that institution's graduate school. Traditionally, students in science and engineering graduate programs have had more access to financial assistance because many of the programs are supported by research grants to faculty. Underrepresented minority students and women, however, have had less access to these sources of funding because they are less likely to be chosen as research assistants on grants.[38]

The availability of financial aid and the access of women, underrepresented minorities, and persons with disabilities to sufficient funding are keys to increasing the enrollment of these students in higher education, both undergraduate and graduate. Additionally, a better reward structure for individuals obtaining SET degrees is needed to offset the competitive lure of better-paying professions that require less investment in terms of time and effort.

Foreign Students

The growing enrollment of foreign students in U.S. schools, particularly at the graduate level, has worried some institutions of higher education. The increasing proportion of foreign students—especially in the sciences and engineering—is made greater by the decline of U.S. citizens who enroll in these fields. Non-U.S. citizens make up 37 percent of full-time graduate enrollment in science and engineering, a figure that goes up to almost half when only engineering is considered. According to the American Institute of Physics, fewer U.S. students entered graduate programs in physics in 1997 than at anytime during the last thirty years (down by 26 percent compared to ten years ago), while the number of foreign students has been climbing.[39]

While the U.S. State Department approves of foreign students as potential good-will "ambassadors" with friendly attitudes toward the U.S., some universities have established quotas for foreign enrollment out of concern about using U.S. taxpayers' money to educate non-Americans while neglecting the development of intellectual talent from our own population.[40] Others worry that developing foreign talent will contribute to the competitiveness of nations with interests unfavorable to the U.S. A recent report revealed that universities provide a greater degree of graduate financial support to foreign students than to U.S. citizens. In the physical sciences, 87 percent of graduate students with temporary visas received support, as did 76 percent of such students in engineering. In contrast, 84 percent of physical science graduate students with permanent visas and 72 percent of such students with U.S. citizenship received support; in engineering, the numbers were 73 percent and 61 percent, respectively.[41]

There are educators, however, who feel that U.S. institutions of higher education need this influx of foreign students to offset the decline in U.S. students. Professors in science departments are concerned that quotas favoring U.S. citizens would force departments to accept less qualified U.S. students over more qualified foreign applicants, thus lowering the quality of their departments. The Committee on Science, Engineering and Public Policy, of the National Research Council, which considered this issue in 1995, made a slightly different point when it concluded that limiting the number of foreigners in science and engineering graduate schools would not necessarily affect the number of Americans enrolling in these programs. Instead, recognizing the global nature of science, engineering, and technology and the value of including foreign talent in academic institutions and industry, the

Committee advocated making graduate, undergraduate, and precollege education stronger as a means of attracting a larger group of qualified American applicants.[42] While there are recognized benefits of enrollment of foreign students in our nation's colleges and universities, the challenge is to control the enrollment so that as the number of women, underrepresented minorities, and persons with disabilities who are interested and prepared to pursue undergraduate and graduate degrees increases, there are enough spaces and resources for their education.

Declining Numbers of Women and Minorities in Computer Science

A study of the supply of information technology (IT) workers in the United States estimates that if the number of women in the IT workforce were raised to the level of men, the enormous shortage of IT workers that currently exists could be filled.[43] The percentage of women earning computer science degrees has dropped steadily since 1984. For example, women were 37 percent (12,066) of degree recipients in 1984 compared to 28 percent (7,020) in 1994. And while the number of bachelor's degrees in computer science declined for both men and women from 1986 to 1996, the drop has been more precipitous for women.[44] There has been a corresponding decrease in master's degrees awarded to women from 1984 to 1994, while doctoral level degrees for women have remained flat (due to an increase of female foreign students at that level).[45]

This decline in women enrolled in formal IT training since 1984 contrasts sharply with the pattern of the late 1970s and early 1980s, when concerted efforts were made to attract women to this field.[46] There has been much speculation about the reasons behind this decline in women entering IT, including: lack of early experience with technology because of lack of access to equipment in high schools; the aggressiveness and violence of computer games used to introduce computers to many students; the image of computing as not conducive to a well-rounded life; the image of IT as being competitive rather than collaborative; the perception of computing as a solitary occupation; a perception that software jobs are not family-friendly; course requirements in gender-biased mathematics and science classes; and lack of women role models.[47]

Many of the reasons that discourage women from IT careers also apply to members of minority groups. In addition, minority students are less likely to have computers at home and therefore are less likely to gain early exposure to information technology.[48]

Affirmative Action

Challenges to affirmative action policies and practices have surfaced in more than half of the U.S. states. These challenges have resulted in legislation or policies that bar the use of race in admissions decisions and financial aid awards to students at postsecondary institutions. Two of the first states to be affected by this affirmative action backlash were California and Texas, where the barring of race in graduate admissions decisions first went into effect for the classes admitted in the fall of 1997. Unfortunately, with this anti-affirmative action movement comes the increased reliance on admission test scores, including the SAT, as the primary selection tool for admission into undergraduate institutions. Students served by affirmative action programs are in many cases those who come from lower income families. Given the high positive correlation between parental income and standardized admission test scores, students previously aided by affirmative action programs may find themselves unable to compete in an environment in which there is a heavy reliance on these tests.[49]

It is still too early to assess the effect of anti-affirmative action policies on the enrollment of women and underrepesented minorities in SET. However, data on first-year, full-time students from the University of Texas system reveal that the proportion of African American and Hispanic applicants admitted in 1997 was significantly less than in 1996.[50] A similar study of the effects of the anti-affirmative action Resolution SP-1 on minority enrollment in the University of California system found that applications, admissions, and enrollments of African American and Hispanic students dropped sharply in the medical and law schools. First-year student enrollment at the more selective institutions also dropped by more than 50 percent in the year following the passage of Proposition 209.[51]

> "The current challenge to affirmative action raises questions about how the nation will solve the occupational and career inequities in one of the fastest growing sectors of America's economy."
>
> **Shirley Vining Brown, Ph.D.**
> *Associate Professor, University of Maryland, Baltimore County Cyber Revolution*

Both Texas and California have implemented policies to counter the effect of anti-affirmative action policies. For example, the Texas Ten Percent Plan, implemented in 1998, entitles the top 10 percent of the graduating class of each accredited high school in Texas to attend the University of Texas at Austin, Texas A&M University, or any other state university. California's Four Percent Plan specifies that students in the top 4 percent of their junior-year class will be eligible for admission to the University of California starting in fall 2001. There are a number of problems associated with this approach. For example, those students from high schools with weak curricula, while having academic potential, may not be well-prepared enough to compete at the undergraduate level.[52] It is important that minority enrollment rates at both institutions be tracked to assess the efficacy of these efforts.

Another criticism of the plans is that they do not affect enrollment in law schools, medical schools, and other graduate and professional schools where the effect of ending affirmative action has been devastating.[53] American Association for the Advancement of Science (AAAS) data from 1994-1999 on first-time graduate enrollment from several top research universities show that in all fields of science and engineering the percent of first-year graduate enrollment continues to decline for U.S. citizens and permanent residents, although the numbers are increasing. This study concludes that an anti-affirmative action climate in the U.S. is one of several factors that have negatively affected first-year graduate school enrollment of underrepresented minorities in SET. Although there has been a rebound in 1998-99, enrollments are still below 1996 levels.[54]

In the short term, the growing challenge to affirmative action policies in post-secondary admissions, particularly at the graduate level, has resulted in lower enrollment rates for African American, Hispanic, and American Indian students.

This affects participation of these groups in SET fields most significantly, since SET fields tend to be more selective. Sources of financial aid, as discussed above, have also been affected. If this trend of lowering enrollment continues, the difficulty in supplying the nation's SET workforce will be exacerbated.

Access to Higher Education Recommendations

Recommendation #1: The Commission recommends aggressive, focused intervention efforts targeting women, underrepresented minority, and disabled students at the high school level, at the transition into postsecondary education, and at the community college transition into four-year colleges and universities.

➢ High School Level: The Commission recommends the expansion and institutionalization of successful school-based and nonschool-based enrichment programs to (a) identify—through the use of authentic, nontraditional assessments that account for the differential experiences of students—potentially able students from under-represented groups that have been plagued by inadequate educational opportunities; and (b) enroll them in accelerated academic preparation programs. Federal, state, and local partnerships should be established to identify and fund these intervention programs at an appropriate level.

➢ Community College: Community colleges enroll close to half of all students that are traditionally underrepresented in SET. The Commission recommends comprehensive and systemic institutional changes to strengthen SET education at two-year colleges and to facilitate transition of SET students from two-year colleges into four-year colleges.

Recommendation #2: The Commission recommends that the federal and state governments significantly expand financial investment in support of underrepresented groups in SET higher education, as well as institutions including, but not limited to, Minority Serving Institutions (Historically Black Colleges and Universities—HBCUs; Hispanic Serving Institutions—HSIs; and Tribal Colleges and Universities—TCUs). Expansion of support to students should come through multiple grant mechanisms rather than loans, to include scholarships, fellowships, and internships. Expansion of support to institutions should include institutional awards, research assistantships, traineeships, and the expansion of proven programs.

➢ The Commission recommends that the federal government enact legislation to expand funding of the Pell Grant Program for SET students and SET education majors. It is recommended that the supplement have the same need requirements as the general Pell Grant, but effectually increase the maximum award to $6,418 for the students identified in this special-needs group. This amount would cover the same proportion of institutional fees that the Pell Grant did in 1979-80,[55] and may have the effect of substantially increasing the incentive for students to pursue SET careers.

The measure of success is parity with respect to population distribution in enrollment, academic performance, and graduation rates of all groups at each level.

PROFESSIONAL LIFE

"...the message here is that it's not going to be sufficient to compete on economics alone; you've got to be an employer of choice...create an environment where you have the notion of a great company, great jobs, great leaders, excellent compensation and lifestyle."

Kenneth Disken
Vice President of Human Resources,
Electronics Sector, Lockheed Martin Corporation

Once women, underrepresented minorities, and persons with disabilities complete SET degrees and begin their careers, what is the situation for them? What in their professional lives accounts for the higher rates of turnover and field switching that characterize these groups' participation in the workforce? In this section the report explores factors that help women, underrepresented minorities, and persons with disabilities to advance and thrive in their positions in industry and academe. The report also identifies obstacles to productivity, advancement, and retention in their chosen professions. Although Asians are overrepresented in the SET workforce given their representation in the population and general workforce, they also face barriers and obstacles to advancement (such as low representation in managerial or administrative positions) in SET professional careers. Because of this, Asians are sometimes discussed on a parallel basis with underrepresented minorities in this section.

First, the report describes, by sex and race/ethnicity, the participants in the SET workforce of 1997 in terms of SET occupations, the sectors in which they are employed, and the salaries they earn.[1]

Underrepresented Groups in the SET Workforce

It's been shown that women, most minorities, and persons with disabilities are less likely than white or Asian men and Asian women to pursue academic SET degrees. Not surprisingly, that disparity continues to show up in the "real world" of the SET workforce. For example,

- no matter what their racial or ethnic background, women make up a smaller percentage of the SET workforce than men;
- in 1997, women were 19 percent of the SET labor force, as compared to their representation in the general workforce at 46 percent;[2]
- the percentage of female life scientists, physical scientists, and engineers remained the same between 1993 and 1997; and

- the percentage of female computer and mathematical scientists dropped from 1993 to 1997.

Table 1 shows the representation in the SET workforce of different racial/ethnic groups.

- Whites, at 82 percent of the SET workforce, were overrepresented in comparison to their presence in the general workforce (76 percent).
- Asians were 11 percent of the SET workforce in 1997 (there were no disaggregated data available on general workforce representation for Asians).
- African Americans and Hispanics each made up 3 percent of the SET workforce—a significant underrepresentation of African Americans and Hispanics compared to their presence in the general workforce of 11 percent and 10 percent, respectively.
- American Indians were 0.3 percent of the SET workforce (there were no disaggregated data available on general workforce representation for American Indians).

These data are illustrative of trends over time; there was little change in distribution of SET in the labor force by race/ethnicity between 1993 and 1997.

Not much data exist for persons with disabilities, but it is known that they were also a small percentage of those in SET occupations—just shy of 6 percent in 1996. Their representation in the general workforce is 14 percent.[3]

Science and Engineering Occupations

As in so many other spheres of life, there are sharp differences, depending on gender and race/ethnicity, in who pursues what SET occupation. In 1997, women constituted 36 percent of life scientists compared to only 22 percent of physical scientists and 9 percent of engineers (Table 1). Across all racial/ethnic groups, a higher percentage of men than of women were computer scientists (73 percent versus 27 percent). Hispanics and African Americans were roughly 2 to 4 percent of most SET occupations. These data show an underrepresentation of African Americans and Hispanics across the board in SET, but Asians were overrepresented among engineers (11 percent) and computer scientists (12 percent). In contrast, persons with disabilities were represented across various science and engineering occupations at similar rates to their overall representation in the SET workforce.

How Leaving Can Encourage Staying

Women continue to bear most of the burden of family care. Workplace policies—whether in industry, government, or academe—that recognize this as a barrier to women's full participation go a long way toward the recruitment and retainment of talented female employees. The Alfred P. Sloan Foundation responded to this challenge with its Pre-Tenure Leave Fellowship Program.

University departments in mathematics, science, engineering, and technology that have appropriate "stopping the tenure clock" leave policies and agree to provide matching funds may apply to the program (the Sloan Foundation and the institution provide a maximum of $40,000 each). Once their department is selected, pretenure faculty members may apply for funds to support full- or part-time leave that is necessitated by planned or emergency family responsibilities, such as childbirth or a dependent parent's illness. The program also provides financial support to pretenure faculty who, having taken leave for family care, want to re-enter the department and continue their research. Funds might be used, for example, to pay for a graduate assistant during or after the leave, to restart a research program, to purchase equipment or supplies, or to pay for child care—almost anything that would allow the faculty member to stay, and succeed, on the tenure track. In addition, the Sloan Foundation offers $5,000 to the faculty member's department for programs that address work-family issues.

While not restricted to women faculty, the Sloan program is the kind of effort that recognizes the invaluable role of women in a workplace that has long been more suited to the habits and needs of men.

Sector of Employment

About three-fourths of all SET workers in the U.S. are employed by industry, with an almost equal number of SET workers in government; educational institutions make up the other quarter. Relative to the composition of the U.S. SET workforce, women are underrepresented in industry: 62 percent of women compared to 73 percent of men. Although there were fewer women than men employed in SET by government and educational institutions, a higher proportion of women are employed in these sectors than are in the U.S. SET workforce as a whole.

Compared to the academic sector, industry has been slightly more successful in recruiting underrepresented minorities but, as can be seen in Table 2, the pool is small. Compared to other groups, Asians were most likely to be employed in industry, although their representation is roughly similar to that of other minority groups and whites. Interestingly, African American, Hispanic, and American Indian SET workers were more likely than other groups to work in federal, state, or local government. SET workers with disabilities were less likely than those without disabilities to be employed in industry (66 percent versus 71 percent), and slightly more likely to be employed in educational institutions (17 percent versus 15 percent).[4]

Salary

Discouragingly, women and underrepresented minorities continue to make less money than white males in SET careers, though this may be improving with time. For example, while full-time employed women scientists and engineers generally earn less than men, the disparity may be due to differences in age, occupation, and

Equity in Action

The female faculty at MIT's School of Science were discouraged. The year was 1995 and despite great gains in the number of undergraduate and postgraduate women students at MIT, the number of female professors in science and engineering had remained static for years. So they appealed for the formation of a committee that would explore the problem—and, surprisingly to some, the dean of science quickly responded.

The committee he established found that subtle forms of gender bias, rather than outright discrimination, were preventing women faculty from succeeding despite professional accomplishments equal to those of the men. Steps taken to address the issue contributed to a 40 percent increase in the number of tenured female faculty working within the School of Science.

MIT's candid admission of a gender bias problem was shocking enough to warrant front-page articles in the *Boston Globe* and the *New York Times*. But MIT has not stopped there. Today, MIT is attempting to replicate its initial success through faculty-run Equity Action Committees empowered both to monitor women's progress across all of MIT and to promptly correct any inequities that are found.

As in the 1995 effort, the Equity Action Committees keep an eye on salary, space, research resources, prizes and awards, teaching and committee assignments, decision-making processes, and more—all areas in which women and men can experience potentially negative differences unrelated to their abilities as faculty members.

Committee members also interview female faculty to identify other possible sources of gender bias. As chair of the MIT faculty, Lotte Bailyn, wrote, "gender discrimination in the 1990s is subtle but pervasive, and stems largely from unconscious ways of thinking that have been socialized into all of us, men and women alike."

MIT's long-term goal is to place women in decision-making positions with men at all levels of the institution. Only then, say MIT officials, will gender bias be eliminated and will role models be provided for all students.

Table 1. Distribution of the U.S. SET Workforce by Sex, Race/Ethnicity, and Subject Area: 1997

Population	Totals*		Life Science		Physical Science		Engineering		Computer Science	
	N	%	N	%	N	%	N	%	N	%
Totals*	3,069,800	100.0	329,200	100.0	289,400	100.0	1,397,100	100.0	1,054,000	100.0
Women	596,900	19.4	119,200	36.2	63,400	21.9	126,800	9.1	287,500	27.3
Men	2,472,800	80.6	209,900	63.8	226,000	78.1	1,270,300	90.9	766,600	72.7
White, non-Hispanic	2,526,600	82.3	277,600	84.3	243,500	84.1	1,155,000	82.7	850,500	80.7
Women	465,900	15.2	97,400	29.6	48,500	16.8	97,200	7.0	222,800	21.1
Men	2,060,700	67.1	180,200	54.7	195,000	67.4	1,057,800	75.7	627,700	59.6
Black, non-Hispanic	98,400	3.2	8,200	2.5	8,500	2.9	36,300	2.6	45,400	4.3
Women	32,300	1.1	3,400	1.0	3,300	1.1	7,800	0.6	17,800	1.7
Men	66,100	2.2	4,800	1.5	5,200	1.8	28,500	2.0	27,600	2.6
Asian	343,400	11.2	33,600	10.2	28,400	9.8	152,900	10.9	128,500	12.2
Women	77,600	2.5	14,500	4.4	8,900	3.1	16,400	1.2	37,800	3.6
Men	265,800	8.7	19,100	5.8	19,500	6.7	136,500	9.8	90,700	8.6
Hispanic	91,700	3.0	8,400	2.6	7,900	2.7	48,500	3.5	26,900	2.6
Women	19,100	0.6	3,600	1.1	2,400	0.8	4,900	0.4	8,200	0.8
Men	72,600	2.4	4,800	1.5	5,500	1.9	43,600	3.1	18,700	1.8
American Indian	8,100	0.3	1,400	0.4	1,000	0.3	3,700	0.3	1,800	0.2
Women	1,600	0.05	400	0.1	200	0.07	400	0.03	600	0.06
Men	6,500	0.2	1,000	0.3	800	0.3	3,500	0.3	1,200	0.1
Persons with Disabilities	169,400	5.5	19,500	5.9	15,900	5.5	79,900	5.7	54,100	5.1
Persons without Disabilities	2,900,300	94.5	309,700	94.1	273,500	94.5	1,317,200	94.3	999,900	94.9

*Figures are rounded to the nearest hundred. Details may not add to total because of rounding.
†Includes both computer and mathematical scientists.
Source: *Women, Minorities and Persons with Disabilities in Science and Engineering: 2000*, NSF, forthcoming.

Table 2. Distribution of the U.S. SET Workforce by Sex, Race/Ethnicity, and Various Sectors of Employment*: 1997

Population	Industry			Local Government			State Government			Federal Government			Educational Institution		
	N	% of sector	% of SET workforce in sector‡	N	% of sector	% of SET workforce in sector‡	N	% of sector	% of SET workforce in sector‡	N	% of sector	% of SET workforce in sector‡	N	% of sector	% of SET workforce in sector‡
Totals†	1,919,800	100.0	71.0	60,000	100.0	2.2	102,900	100.0	3.8	210,200	100.0	7.8	410,200	100.0	15.2
Women	323,800	16.9	61.9	13,100	21.8	2.5	23,300	22.6	4.5	41,600	19.8	7.5	121,700	29.7	23.3
Men	1,596,000	83.1	73.2	46,900	78.2	2.2	79,700	77.5	3.7	168,600	80.2	7.7	288,500	70.3	13.2
White	1,601,900	83.4	71.3	42,700	71.2	109	82,800	80.5	3.7	173,600	82.6	7.7	343,800	83.8	15.3
Asian	200,300	10.4	71.7	10,800	18.0	3.9	10,000	9.7	3.6	17,100	8.1	6.1	41,100	10.0	14.7
Black	58,100	3.0	65.1	2,700	4.5	3.0	6,000	5.8	6.7	11,400	5.4	12.8	11,100	2.7	12.4
Hispanic	54,700	2.8	67.4	3,300	5.5	4.1	3,100	3.0	3.8	7,200	3.4	8.9	12,900	3.1	15.9
American Indian	4,600	0.2	63.0	400	0.7	5.5	500	0.5	6.8	700	0.3	9.6	1,100	0.3	15.1
Persons with Disabilities	96,200	5.0	65.8	3,500	5.8	2.4	7,900	7.7	5.4	13,800	6.6	9.4	24,800	6.0	17.0
Persons without Disabilities	1,823,600	95.0	71.3	56,500	94.2	2.2	95,100	92.4	3.7	196,400	93.4	7.7	385,400	94.0	15.1

*Sectors not covered here include private nonprofit organizations, self-employment, the U.S. military, and other noneducational institutions.

†Figures are rounded to the nearest hundred. Details may not add to total because of rounding.

‡Percentages of the total population of each group in the U.S. SET workforce employed in each sector.

Source: Tabulations by National Science Foundation/Science Resources Studies, SESTAT 1997.

highest degree. The overall median salary in 1997 of full-time women in the SET workforce was $48,800—much lower than that for men ($59,000). But within certain occupations and younger age categories, the median salaries of men and women are more similar. On the other hand, the gap in salary between men and women tends to widen with age, except for engineers employed in business or industry.

Similar disparities exist for SET salaries among racial/ethnic groups, as can be seen below in the median salaries from 1997 for each group:

- Whites–$56,700;
- African Americans–$49,500;
- Hispanics–$52,000;
- American Indians–$50,000; and
- Asians–$57,000.

Encouragingly, median salaries of SET workers with disabilities are similar to those without disabilities ($56,000 and $55,000, respectively).

For the most part, these salary patterns for women, underrepresented minorities, and persons with disabilities in the SET workforce hold across the various science occupations and age categories, with SET professionals in these groups earning less than their white and Asian male colleagues.[5]

Professional Life in Industry and Government

Primary Work Activity

Because men are more likely than women to be engineers and physical scientists, more men than women employed by industry identify research and development as their primary or secondary work activity (59 percent versus 51 percent). Women in industry, however, are as likely as men to be in management or administration (45 percent versus 47 percent), though they tend to oversee smaller staffs (seven subordinates versus eleven), one sign of relative influence within an organization. In government, women SET workers are less likely than men to be primarily engaged in management (46 percent versus 54 percent).

There are also differences among racial/ethnic groups in terms of primary work activity. African American and Asian SET workers in industry are more likely to be primarily engaged in computer applications. However,

Disability Management Retains Workers, Lowers Costs

Recognizing the need to reduce the costs associated with workplace disability while also retaining the skills that disabled workers have to contribute to their companies, employers in the 1980s began developing integrated disabilities management programs to provide a unified set of policies and programs. Such integration encompasses illness and injury prevention efforts, rehabilitation, medical case management, and return-to-work programs for all causes of disability, whether job related or not. The goals: early intervention, coordination of medical care, and the facilitation of return to work at the earliest medically appropriate time.

Since 1996, the Washington Business Group on Health in partnership with Watson Wyatt Worldwide has conducted an annual survey of corporate disability management practices called Staying@Work. The survey has found that the percentage of large companies with such programs rose from 26 percent in 1996 to 43 percent in 1999. Job accommodation costs were less than 1 percent of payroll, and by applying disability management "best practices," employers saved 15 to 20 percent of disability costs.

Four best practices were found to correlate with the best return on investment:

- policies that allow for transitional or modified duty upon an employee's return to work;
- the availability of disability case management services;
- a single point of contact for all benefit claims; and
- a single manager for all disability benefit programs.

A survey conducted by Cornell University in 1999 showed that disability management programs help companies comply with the Americans with Disabilities Act. The programs help to create a warmer, more accepting workplace climate for employees with disabilities as well as greater awareness among supervisors of how accommodations can reasonably be done.

they are less likely than other groups to be engaged primarily in management or administration. Among those few underrepresented minorities who have reached the ranks of industrial management, Asians and American Indians had fewer subordinates than scientists and engineers from other racial/ethnic groups. The median number of direct and indirect subordinates is six for Asians, five for American Indians, ten for Hispanics and whites, and twelve for African Americans.

Minority women SET workers in industry have similar work activities to white women, although Asian women are more likely to be primarily involved in research and development, and less likely to be primarily engaged in management or administration. Women, regardless of racial/ethnic group, were more likely than men to report computer applications as primary or secondary work, and less likely than men to report research and development activity.

Once again, the existence of a disability appears to have little effect on this aspect of professional life, which seems to suggest that if persons with disabilities make it this far they find the support they need to succeed. The primary or secondary work activity of 55 percent of SET workers in industry with disabilities is research and development, compared with 58 percent of those without disabilities. Forty-three percent of SET workers with disabilities and 47 percent of those without are primarily or secondarily engaged in management or administration. The median number of subordinates for persons with disabilities is eleven, as compared to ten for those without disabilities.

Among SET workers employed in the government sector, Asians are less likely than those in other racial/ethnic groups to be primarily engaged in management or administration. Forty-five percent of Asians compared with 57 percent of African Americans, 56 percent of Hispanics, and 53 percent of whites reported management or administration as a primary or secondary work activity. In this sector, 52 percent of persons with disabilities and 53 percent of those without disabilities are primarily engaged in management or administration.

Representation in High-Level Corporate Positions

Women and underrepresented minorities are severely underrepresented in the highest levels of industrial management. A 1998 census of women corporate officers found that only 11 percent of all corporate officers were women, and of the forty corporate officers who held senior titles in research, only two were women.[6] Hispanic representation at the officer level is also low, an astounding 0.6 percent of total officers in the Fortune 1000 companies. Of these, 88 percent are men and 12 percent are women.[7] Data were not available on the number and percentages of individuals from other underrepresented groups in the highest ranks of corporate management. 1996 data on the composition of boards of the Fortune 1000 companies, however, show similar underrepresentation, with African Americans comprising 3.5 percent, Hispanics 1.0 percent, and Asians 0.4 percent of boards. Ten percent are women.[8]

There is a direct correlation between the number of women corporate officers and the number of women on corporate boards. Corporations with more women on their boards tend to have more women corporate officers as well.[9]

It is likely that a similar link would be found between the number of underrepresented minorities on corporate boards and the number of senior executives who are members of these groups.

Issues Relating to Women

Much more is known about factors that discourage SET women—including women of color—from entering and remaining in industry than about minority males and persons with disabilities. Catalyst, an organization that conducts studies on women in a variety of fields, has contributed much insight into workplace conditions that affect women scientists and engineers. A recent study by Catalyst[10] of successful and highly visible senior women scientists employed in industry addressed the paucity of women scientists in Fortune 500 companies. As part of the study, the participants identified several reasons why women scientists may or may not choose careers in business.

- *Female graduate students in the sciences remain uninformed about potential careers in business.* Women said that they were given very little or no information about the corporate job market upon the completion of their academic studies. They also claimed that their university advisors prepared them solely for academic careers.

- *And yet, academia is viewed by many as unwelcoming to women scientists.* Despite the fact that their advisors tended to steer them toward academia rather than business, many of the women who participated in the study stated that they chose the business arena simply because they did not feel welcomed into academia.

- *Companies that are seen as "female-friendly" are more likely to be successful in recruiting women scientists and engineers.* Development of an environment in which women feel respected and valued within the company is an important recruitment—and retention—strategy. Policies that support family life, mentoring, and career development were seen both by organizations and women employees as contributing to a "female-friendly" workplace.

- *Women were attracted to applied science and product development.* They perceived industry as offering a faster-paced and more diverse career path, together with economic stability and liberation from the necessity of writing grant proposals to support research projects.

Data on the exit rate of women from SET positions in industry were reported in a National Research Council document in 1994[11] (retention data on underrepresented minorities or persons with disabilities are not available). The picture is gloomy and suggests a need for innovative intervention. Women scientists and engineers in industrial jobs are more likely to leave technical occupations—and more likely to leave the labor force altogether—than women who work in other sectors. Attrition data on women in industry show that their exit rates are not only double those of men (25 percent versus 12 percent), but they are also much higher than those of women in other employment sectors.

For example, women scientists and engineers in public employment exit at a rate of 13 percent, while those in nonprofit organizations have a 16 percent attrition rate. Women in industry are 30 percent more likely than women in other sectors to exit SET jobs for other types of employment, and they are 80 percent more likely than women in government or the nonprofit sector to exit SET jobs and actually become unemployed. Finally, women employed in industry are about 50 percent more likely than women in other sectors to exit the labor force entirely.

Other studies describe some of the barriers to advancement and retention faced by women, including the following:

- *Absence of female role models.* Because women scientists are severely underrepresented among senior managers of American corporations, female role models are rare. For example, among 40 corporate officers who held senior titles in research when Catalyst conducted its 1998 Census of Women Corporate Officers and Top Earners,[12] only two were women.
- *Isolation.* Women engineers and scientists often find themselves the sole woman in their group during both academic training and their professional careers. The lack of a critical mass in industry for women scientists makes it hard for them to tap into informal networks that could lend them support.
- *Risk-averse supervisors and stereotypes.* Women scientists' progress early in their careers may be impeded by their having to prove their technical credibility again and again. This may be the result of stereotyping of women's abilities as well as the perception that promoting women is riskier than promoting men. The perception that women cannot "do science" is one that women scientists in corporations have to battle constantly. The competencies and traits associated with success in science are generally viewed as male attributes.
- *Differences of style.* Different styles of communication may affect how employees' ideas are received. Corporations tend to reward an aggressive style of speaking and often discount language that is not certain. Women who exhibit assertive style, however, run the risk of being seen as inappropriately combative.
- *Exclusion from informal networks.* Women are often excluded from all-male networks, which often focus on sports activities that may not appeal to women as well as weekend events that can be difficult to attend because of women's larger share of family responsibilities.
- *Lack of mentoring.* Mentors and sponsors are of vital importance to women's advancement in the corporation. It may be difficult, however, for women to find mentors through the same informal mechanisms used by men, especially since individuals tend to mentor people who are very much like them. Because having a mentor is critical to advancing into management roles, women are at a disadvantage in predominantly male environments.

> "We cannot [define] the future [by] a narrow slice of the population. We must all be represented. We should all benefit."
>
> **Anita Borg, Ph.D.**
> *President and Founder*
> *Institute for Women and Technology*
> *Research Staff, Xerox Corp.*

- *Lack of line or general management experience.* Line roles (sales and manufacturing functions) involve direct profit-and-loss responsibility in contrast to staff positions (research and development) that support the production line. Having line experience is critical to advancing further in the corporation. Catalyst has found that women are encouraged to enter staff roles and find it difficult to obtain line responsibility.

- *Work/life balance.* Women with spouses and/or children struggle to keep up with the fast-paced work environment as studies have shown that, unlike men, they remain primarily responsible for family and home care. Even in a firm with family-friendly policies, women are concerned that they cannot pursue their science careers and take family leave at the same time without risking the perception that they are less committed to their careers than their male colleagues.

Issues of work and family balance are of paramount concern to women employed in SET fields. Policies and benefits such as extended parental leaves, part-time work options, on-site child care facilities, and greater scheduling flexibility are needed. Access to quality, reliable, affordable child care is key to the retention of working parents. And as previously pointed out, quality child care also impacts the workforce development over the long term. Women feel that in order to be successful they must exceed expectations, be flexible, and work hard to make male supervisors and coworkers feel comfortable around them.[13] If companies wish to attract and retain talented women in their SET workforce, they must do their part to equalize the "success equation" with creative solutions of their own—policies and practices that will help women scientists overcome the difficult obstacles to success that have been identified above.

Issues Relating to Underrepresented Minorities

Underrepresented minorities face many of the same barriers that impede women and persons with disabilities from experiencing success in SET careers, although there are specific issues relating to this group.[14]

In the 1970s, industry stepped up its efforts to recruit underrepresented minority science and engineering professionals. In fact, government and industry opened up opportunities for some underrepresented minorities before the major, predominantly white educational institutions did. As reflected in the data, underrepresented minorities are now much more likely to choose jobs in industry than in academe.[15] Of course, one factor leading to this outcome is that advanced degrees are typically not required in industry jobs. In addition, financial pressures lead a disproportionate amount of underrepresented minorities to seek employment after the first degree.

Barriers to advancement and retention identified by underrepresented minority professionals in SET careers include:[16]

- not having an influential mentor or sponsor;
- lack of opportunities for informal networking with influential colleagues;
- lack of company role models who are members of the same racial/ethnic group;

- lack of high-visibility assignments;
- stereotyping of some minority groups as incapable of doing science; and
- difficulty in securing grant monies even with a proven track record of producing high-quality research.

Underrepresented minority women SET professionals, while facing some of the same obstacles as white women, experience discrimination due to both race and sex, the so-called "double bind." This results in their being doubly disadvantaged in terms of income.[17]

Professional Life in Academe

Institution, Rank, and Tenure

Within educational institutions, women differ from men in terms of academic rank, tenure, and the type of school in which they are employed. In 1997, women were slightly more likely than men to be employed in primary or secondary schools (1.8 percent versus 1.6 percent). Women were also more likely than men to be employed in two-year colleges (16 percent versus 10 percent). In four-year colleges and universities, women SET academics hold fewer high-ranking positions than men and are less likely to be full professors but more likely to be assistant professors.

For example, among full-time ranked Ph.D.s, 50 percent of men and 23 percent of women were full professors. Women were also less likely than men to be tenured. Twenty-nine percent of women SET academics employed full-time in four-year colleges and universities were tenured, compared with 58 percent of men. Minority women were less likely than white women and less likely than men of any racial/ethnic group to be full professors. African American women, however, were the most likely of all women to be tenured (40 percent versus 32 percent for white women, 29 percent for Hispanic women, and 17 percent for Asian women; however, the actual number of minority women professors is very small, so such statistics can be misleading).

> "Bringing underrepresented individuals into the emerging mainstream of 'smart jobs' is not only a matter of equity. It is crucial to avoid the schism that lack of access and technical skills will mean in the Knowledge Age."
>
> **David R. Pierce, Ph.D.**
> *President and CEO*
> *American Association of Community Colleges*

When it comes to federal research funding, such disparity disappears. Ranked female Ph.D.s employed full-time in four-year colleges or universities were as likely as their male colleagues to receive federal grants or contracts (46 percent for both groups).

Racial/ethnic groups also differ in terms of academic employer. Among all SET academics in 1997, Asians were less likely than other groups to work in primary or secondary schools (1.2 percent versus between 1.6 percent and 4 percent of other groups) or in two-year colleges (4.6 percent versus between 13 percent and 17 percent of other groups). Asian Ph.D.s differ from other groups in terms of their academic employer. They are more likely than African American or Hispanic Ph.D.s to be employed in the larger, research-focused universities (Research I), while African American Ph.D.s are less likely than other groups to work in these research-oriented universities, and more likely to be employed in colleges or universities that place less emphasis on research and that offer a more limited range of graduate programs.

Among full-time ranked Ph.D.s in four-year colleges or universities, 38 percent of Asians, 32 percent of African Americans, and 31 percent of Hispanics, compared with 48 percent of whites, were full professors. African American, Hispanic, and Asian Ph.D.s in four-year colleges or universities were also less likely than whites to be tenured. African American and American Indian Ph.D.s employed in four-year colleges or universities are less likely to have received federal grants or contracts. Among Ph.D.s working full-time in four-year colleges or universities, those with disabilities are actually more likely than those without disabilities to be full professors and to be tenured (although this may be a function of age since older faculty are more likely to have a disability). Ph.D.s with disabilities, however, are less likely than those without disabilities to be supported by federal grants or contracts.

As in industry and government, women, underrepresented minorities, and persons with disabilities are not represented in the SET academic labor force on par with their presence in the in the workforce at large. Equally distressing, salaries for members of these groups (with the exception of persons with disabilities) tend to be lower than those for white men even when they work in the same occupations. Additionally, when factors of age and experience are considered, they are not sufficient to explain the existing disparities.[18]

In sum, full professorship and tenure are still awarded more to white males at the expense of women and underrepresented minorities, even those with the same level of education and with jobs at the same type of institution. And while female and male academic researchers are receiving equal support from federal grants and contracts, African Americans, American Indians, and persons with disabilities are lagging behind other groups in this regard.

Issues Related to Women

What factors influence a woman's SET career attainment in academe, relative to men? Studies suggest that the key variables are research productivity and organizational/environmental factors. Lower publication rates have often been used to justify women's lower rank, salary, and tenure rates. At issue is the balance between quantity and quality. Although women typically publish less than men, they produce stronger publications that garner more citations than do their male colleagues.[19]

Because science and engineering are performed in settings that require human and material resources, organizational factors may be important in determining women's career attainments. SET professionals do not work in a cultural or social vacuum—values and biases within the larger SET community hinder some and help others when it comes to status and performance. Academic institutions, especially the SET departments, continue to be a male milieu in which men share traditions and women are more likely to be outsiders. Women scientists in a national survey report significantly fewer interactions with faculty, fewer resources, and heavier teaching loads than their male colleagues.[20] Women are also less likely to form a mentoring relationship with a more senior faculty member. A study by the Massachusetts Institute of Technology, which described the marginalization of senior female science faculty at MIT, also documented differences in salary, space, awards, resources, and response to outside offers between men and women science faculty, with women receiving less despite professional accomplishments equal to those of their male colleagues.[21]

In addition to salary, faculty rank, and tenure, working conditions contribute a great deal to the degree of satisfaction a worker feels about his or her employment. In turn, satisfaction with working conditions contributes significantly to women faculty's decision to remain at an institution or in academe. Most faculty work long hours—an average of at least 50 hours per week[22]—although women faculty are likely to work 80 hours or more per week with 35 of these focused on housework and children.[23] Women who have children under the age of three work an average of 90 hours per week.[24] Family demands such as child care, household responsibilities, and elder care, which are much more the responsibility of women than of men, combine to force women into making difficult choices between family and career.[25]

> "To the extent that engineering is a pale male profession, which it largely is, it is impoverished."
>
> **William A. Wulf, Ph.D.**
> *President, National Academy of Engineering*

Women on the tenure track still find childbearing to be an enormous impediment to achieving tenure and sustaining an academic career. A study of women professionals found that the birth of a first child is a turning point in the careers of many women. Although over three-fourths of the women in the study felt that reducing working hours was detrimental to their careers, most of them reported reducing their work hours after the birth of a first child. Of the women who were mothers, over half changed jobs or specialties to accommodate family responsibilities.[26]

Conflicting demands of work and family affect women's ability to function as a professional and as a family member. Is it any wonder that without a sea change in the way women are supported in their SET careers, they will continue to drop out to the diminishment of the nation's knowledge base?

Issues Relating to Underrepresented Minorities

As with women, the career attainment of underrepresented minorities in SET is affected by both research productivity and organizational/environmental factors. Underrepresented minority faculty members tend to publish less often than nonminority researchers, which again, is a barrier to career advancement.[27] While underrepresented minority males may not face the same time constraints that women do, plausible reasons for this lower publishing rate are not hard to discern.

The two main factors affecting career advancement for underrepresented minority SET professionals in academe are interactions with other faculty in the department and the school's overall racial climate. Because of their relatively small numbers, underrepresented minorities in SET, like women, are outsiders in the world of academic science. Career-enhancing collegiality, therefore, is a significant

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challenge for underrepresented minority faculty. Too many white faculty continue to believe that underrepresented minority faculty were hired because of affirmative action regulations and not on merit. Related to this belief is the conjecture that minorities are not as qualified as white academics and that the presence of more than one underrepresented minority faculty member in a traditionally mainstream program will lower the academic standing of the department (dubbed the "one-minority-per-pot syndrome").[28] Such attitudes can poison the quality of interaction between underrepresented minority and white faculty.

Moreover, many underrepresented minority faculty members consider the overall racial climate at their universities to be poor. Most agree that membership on faculty search committees is insufficient to address the problem, that underrepresented minority faculty representation in their departments and at their institution is low, and that their opportunity for advancement is hindered, not helped, by their racial/ethnic backgrounds. Issues of isolation, absence of other underrepresented minority faculty and students, and lack of mentors also contribute to underrepresented minority faculty members' perception of a less-than-welcoming environment on predominantly white campuses. It is not hard to understand how the scholarly productivity of underrepresented minority faculty could be negatively affected in a work environment where such an implicitly or explicitly hostile racial climate exists.[29]

Issues Relating to Persons with Disabilities

Many of the barriers to recruitment, retention, and advancement in SET careers that have been discussed for women and underrepresented minorities apply just as well to persons with disabilities. As with gender and color, a person's physical capabilities can set him or her apart from colleagues in a way that discourages networking and other forms of career-enhancing support. Also, disability status overlaps with gender and minority status in significant ways. For example, women with disabilities and minorities with disabilities are least likely to be employed.

Other than the data reported at the beginning of this section on persons with disabilities, additional information or research studies on the work lives of this group of professionals were unavailable. The lack of statistical information on the professional lives of persons with disabilities, as well as lack of data for this group with regard to school experience and outcomes at all levels, points out a critical failure in the ability to evaluate disability as a component of diversity.

What is known is that labor force participation for this population continues to decline (35 percent of males and 32 percent of females who have serious disabilities work compared to 95 percent of males and 81 percent of females who do not have a serious disability).[30] Our research on this group must vastly improve if barriers to participation in SET are to be understood.

Family-Friendly Policies and Practices

Changes in the workplace, the work habits of family members, and family life have combined to create demands on employers to support employees both in and out of the workplace. Over 60 percent of all women now work (46 percent full-time) and 60 percent of all mothers with children under six are in the workforce. The number of two-parent families has been declining, together with the number of families with stay-at-home wives. In 1998, single parents headed 27 percent of family households with children under 18.[31]

Other changes in the composition of family life have affected today's worker. Because of greater workforce geographical mobility, extended families that occupy the same household are a thing of the past. Changes in the workplace are also affecting scientific professionals. Organizations are becoming increasing unstable because of international competition and deregulation. As a result, restructuring resulting in temporary, part-time work is becoming more common. Because of their greater vulnerability to the consequences of a changed workplace (for example, they are more likely to hold part-time or short-term positions), women and underrepresented minorities of both sexes have been more affected by these changes.[32]

Federal and state governments and private employers have responded to workers' needs for relief from the burdens imposed by modern family life by creating so-called "family friendly" policies. One response by the federal government was the Family Medical and Leave Act (FMLA) of 1993, which provides for workers to take unpaid leave to attend to family emergencies and other demands relating to family life. At the time of the passage of the law, 34 states had similar laws and a large number of employers had in place leave policies of one type or another. As of 1998, 38 states had some form of family and/or medical leave laws, many of which were more generous than the FMLA in terms of leave time, qualifications for leave, and size of organizations covered by the legislation. There is consensus, however, that the federal law further expanded company leave policies for the workforce as a whole and that in the course of the 1990s more workers applied for and used this type of leave.[33]

A recent study of work and family life has found that the quality of work and the supportiveness of the workplace are the most powerful predictors of productivity.[34] With the increase in dual-earner families where both partners work full-time, worker access to affordable, reliable, quality family care is essential, particularly if workers have children under eighteen or other dependents. Only a small number of workers, however, has access to dependent-care benefits such as child care information and referral services (20 percent); elder care information and referral services (25 percent); on- or near-site child care services (11 percent); financial assistance for purchasing child care services (13 percent); and dependent-care assistance plans (29 percent).

A major finding of the 1997 National Study of the Changing Workforce was that work life is an important source of employees' personal problems.[35] The study concluded that special assistance programs—designed to help employees solve personal problems—that do not also address how the employees' jobs contribute to those problems may be insufficiently helpful in improving employee job performance. This finding speaks to several of the points made in this report with respect to women, underrepresented minority, and disabled scientists and engineers and the influence that workplace environment has on their success.

For professionals in science and technology, regardless of sector, the work pace is rapid and the activities unceasing. Longer hours than average are the norm and physical presence still denotes dedication to the job at hand. Women and underrepresented minorities, who more often have conflicting family demands that include child-bearing, child-rearing, and care of elderly parents, may be more likely to take leave. In the culture of the scientific and technological workplace, taking leave still reflects poorly on science professionals' commitment to science and may lead to a judgment that people who take leave have a poor potential for scientific growth and development. How do employers change the culture and environment of the SET workplace, which developed when white males were the employee norm, to accommodate the needs of underrepresented groups? This challenge has yet to be successfully addressed by any of the sectors in which SET workers are employed.

Professional Life Recommendation

The Commission recommends that both public and private SET employers be held accountable for the career development and advancement of their employees who are women, underrepresented minorities, and persons with disabilities.

- ➢ The Commission recommends that the degree of participation, comparative pay, level of pay at hire, career development, and advancement of women, underrepresented minorities, and persons with disabilities in the SET workplace be reported yearly.

- ➢ The Commission recommends that SET diversity be a strategic goal in the private, public, nonprofit, and academic sectors. It also recommends the adoption of policies promoting a workplace environment that is inclusive and respects diversity. The measure of success for diversity in the workplace is parity among all subgroups in SET employment, retention, and promotion rates.

- ➢ The Commission recommends the development of a system of high-level, prestigious awards in order to recognize exemplary achievement by organizations that encourage among their employees a healthy balance between their work and personal lives through flexible, functional workplace policies and attitudes.

A national model should be developed of a workplace environment that is inclusive, values differences, and has flexible workplace policies. The measure of ultimate success is parity relative to the general work force population distribution at different workplace and management levels, and equity in retention, pay, and promotion rates.

PUBLIC IMAGE

"The current image of [computer scientists as] smart, rich, skinny, thick glasses, pale, no life, no people skills…is completely inaccurate and discourages many young people, including the vast majority of young women."

Maria Klawe, Ph.D.
Dean of Science, University of British Columbia

At a series of town meetings held around the country by the National Dialogue on the Information Technology Workforce, participants said that young people's attitudes about science and technology careers are shaped by distorted, negative images of the types of people who work in those fields. Despite decades of social change, the general perception remains that IT workers, scientists, and engineers are unusually intelligent, socially inept, and absent-minded "geeks" or "nerds." Advertisers, the entertainment media, and the news media have an influential role in shaping these perceptions. Caricatures of (mostly male) scientists continue to appear on billboards, in magazine ads, in movies, and on television sitcoms. The news media also contribute to these distortions with stories that too often emphasize scientists and engineers as otherworldly geniuses working in isolation from society.

To make matters worse, the relative absence of women, underrepresented minorities, and persons with disabilities in SET careers, as documented in this report, makes it easier for the media to overlook those underrepresented individuals who *are* succeeding in SET, which only serves to perpetuate the problem. One reason that female, underrepresented minority, and disabled children—as well as the adults who support them—don't think of science as a career to which such children can aspire, is that people who look like them are so seldom portrayed as scientists. As one 15-year-old girl commented: "Men are scientists. It is a masculine job career. Women don't go into it because being a scientist will make them look bad."[1]

The Image of Scientists and Engineers

Among School Children

Over four decades ago, anthropologists attempted to systematically describe the standard image of the scientist held by a population of American high school students. The anthropologists drew a composite portrait based on their research that describes the scientist as:

> [A] man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses…he may wear a beard…he is surrounded by equipment: test tubes, Bunsen burners, flasks and bottles, a jungle gym of blown glass tubes and weird machines with dials.[2]

Though modernized a bit, the stereotype of scientists as "diabolic madmen, distinguished professors, harmless eccentrics, learned buffoons, and fashionable dilettantes," as one anthropologist described it, may still be seen today on the screen and on the printed page.[3] Research with children using the Draw-a-Scientist Test (DAST) has documented that this stereotypical image of the scientist emerges by the second grade and becomes more pronounced as children grow older. Studies have also shown that these concepts are deeply rooted and persistent: stereotypical images held by undergraduate and graduate students do not differ significantly from those held by younger students, even though these older students have encountered real-life scientists in college.[4]

> "Many of the newest generations of women primatologists talk about the positive effects on them as children of seeing *National Geographic* coverage of Jane Goodall [and] Dian Fossey."
>
> **Linda Fedigan, Ph.D.**
> *Professor, University of Alberta*

Strikingly, all the research on this topic describes the virtual absence of females and members of racial/ethnic minority groups in the students' drawings of scientists, no matter what grade level. Only female students drew female scientists, and this occurred rarely. A few underrepresented minority scientists were depicted as well, presumably by underrepresented minority students. The assumption that scientists are all able-bodied is so established that the studies themselves did not note the absence of persons with disabilities in the students' depictions. In response to speculation that the students failed to depict diverse scientists because of the small number of females and minorities in scientific professions, researchers point to the absence of Asian scientists in the drawings, despite Asians' overrepresentation in many SET professions.

The attitudes of girls, in particular, regarding scientists and engineers have been influenced by the lack of female scientists in the media. In the absence of role models, many girls do not see themselves as successful "doers" of science, and tend to view science and technology as unsuitable careers and personally irrelevant to their lives. Nonetheless, studies have shown that these perceptions can be reversed through concerted interventions. Exposing children to researchers who do not look like the stereotype, for example, either through field trips to labs or by bringing scientists into the classrooms, has been shown to broaden the children's view of who can be a scientist. When asked to draw what a scientist looks like months after such interventions, these students portray a more diverse range of people.[5]

Among the General Public

Twenty years ago, in summarizing two decades' worth of surveys, researchers concluded that the general public's attitudes toward science and technology were overwhelmingly favorable.[6] Today, 75 percent of Americans believe that the benefits of scientific research outweigh harmful results, and nearly 70 percent of American adults say they are interested in science and technology—the highest level ever measured.

Yet, while more Americans than ever seem to appreciate the overall benefits of science and technology, their grasp of what scientists and engineers actually do remains abysmal, a fact that has ramifications for how scientists and engineers themselves are perceived. A recent Harris Poll conducted by the American Association of Engineering Societies revealed that 45 percent of Americans feel uninformed about engineers and engineering. When the respondents were broken down by sex, almost 60 percent of women compared to nearly 40 percent of men felt that they were "not very well informed about engineering and engineers."[7] A similar lack of understanding reigns in the public's grasp of science. In one 1998 study, only about 27 percent of American adults had a minimal understanding of the nature of scientific inquiry.[8]

The general public depends on the media for most of its science-related information, but clearly much is being lost in translation when so few people are familiar with science or know what scientists do. Public understanding of science is essential if citizens are to fully participate in the high-tech economy and in a democratic society struggling to contend with science-related policy issues such as genetically modified foods and global warming. Investment in nontraditional, informal education of the public is needed to broaden the learning community around SET issues. But public understanding of science is also important to the degree that it influences people's understanding of who scientists and engineers are—or could be. Efforts to improve Americans' science- and technology-related literacy should simultaneously broaden their understanding that women, underrepresented minorities, and persons with disabilities are capable of contributing to the scientific enterprise in equal measure.

Scientists and Engineers on Television

Television is particularly influential in affecting children's attitudes and behaviors. This is unfortunate because the images of scientists and engineers conveyed by prime time television are too often both negative and inaccurate. The scientists portrayed on Saturday morning children's television in the U.S. have been described by the late astronomer and science populist Carl Sagan as "driven by a lust for power, or gifted with a spectacular insensitivity to the feelings of others." The media portrays scientific progress as hazardous, and scientists are often depicted as foolish, inept, or villainous.

Even children's educational science programs on television perpetuate the stereotype of the scientist as male. A study of images of science and scientists in *Beakman's World* on CBS, *Bill Nye, the Science Guy* on independent stations, *Mr. Wizard's World* on Nickelodeon/MTV, and *Newton's Apple* shown on PBS found that these shows had

Visualizing the Possibilities

In May of 1999, the National Academy of Engineering (NAE) convened a two-day Summit on Women in Engineering attended by 175 top decision-makers from all sectors of the economy, including the media. Citing greater diversity in the engineering workforce as a crucial business imperative, the group devised a framework for action that would, among other things, identify promising practices in the schooling of engineers and create an assessment tool to evaluate the "climate" for diversity across government, academia, and industry. Such issues are crucial, the participants said, but the first step for post-Summit action should be to address the "image challenge" posed by the stereotype of engineering as a field unsuitable for girls and women.

Toward that end, participants from such wide-ranging organizations as NASA, General Electric, WGBH (Boston's public broadcasting station), DuPont, IBM, and numerous universities and professional societies agreed to pursue development of strategies that would change the public face of engineering by showing a diverse range of women participating in a broad spectrum of engineering tasks. Among the suggested image-related strategies were the adoption of marketing research to develop short- and long-term public relations campaigns and the implementation of cross-cultural studies to determine why other nations have better success rates of educating girls to become engineers.

To ensure that the Summit's proposals don't just end up as lofty rhetoric, the NAE has formed two new entities: the Committee on Diversity in the Engineering Workforce and the Action Forum on Diversity in the Engineering Workforce. The Committee is designing a workshop for early 2001 to set standards for how to measure best practices and organizational climates that encourage diversity. The Forum is considering numerous activities, including the creation and implementation of an advertising campaign.

three times as many male as female characters and twice as many adult male scientists as female scientists. Furthermore, of the female characters who were observed, almost all had secondary roles as students, lab assistants, or science writers. Few were expert scientists or held prestigious positions within the scientific community.[9]

Because of its vast reach, commercial television has the greatest potential for influencing the public view of scientists. A longitudinal study conducted for the U.S. Department of Commerce found that only 2 percent of characters in prime time dramatic television from 1994-1998 were scientists.[10] Despite their small numbers, those scientist characters did not escape unflattering treatment. The study also found that while television doctors were among the most positively portrayed characters, other scientists suffered from a greater share of ambivalent and troublesome portrayals. They were older, stranger, and less sociable than other depicted professionals, and most likely to be foreigners. They were also most likely to be killed among all occupational groups, including the army, police, and private investigators. In a companion survey of fifteen hundred television viewers, the study's researchers found that the more people watch television, the more they think scientists are odd and peculiar.

Math is Power

The image on the poster is of a dark, youthful hand raised in a fisted power salute, with the letters M, A, T, and H plainly written just below the knuckles. "Demand it," says the inscription over the fist. And below: "Math is power."

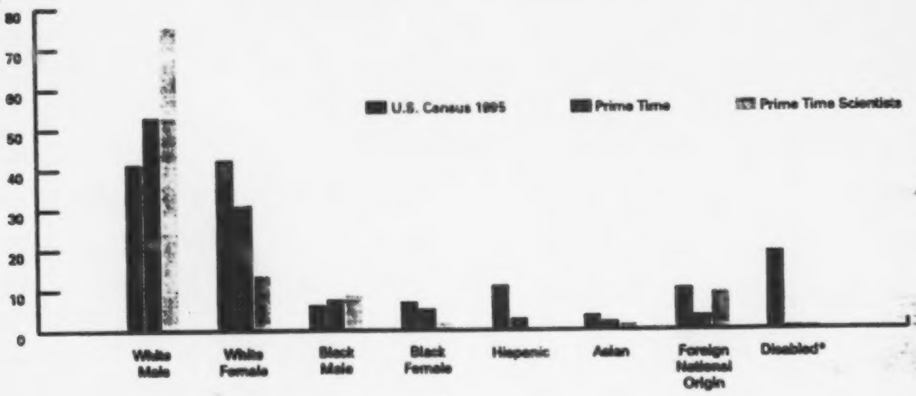
The poster—and a series of related broadcast, print, and Web advertisements—are the brainchild of the National Action Council for Minorities in Engineering (NACME) working in partnership with the Advertising Council. Launched in 1995 with an investment of $2.3 million, the *Math is Power* national public service campaign aims to persuade students and their families—especially those underrepresented in SET—to demand access to the advanced mathematics courses that are critical to successful careers in science, engineering, finance, and more.

In a recent survey conducted for NACME by Louis Harris and Associates, more than 50 percent of American middle and high school children said they plan to drop math as soon as the option is presented to them. Of those students who would drop math, more than half were interested in careers such as engineer, computer programmer, or astronaut. NACME developed *Math is Power* to bridge the gap between the careers students say they want and the disastrous educational choices they make in the absence of a required curriculum and adequate guidance.

A variety of public and private organizations help fund the campaign, whose ads also appear in newspapers and magazines, on bus shelters and mall walls, and in classrooms and corporations. The toll-free 1-800-97NACME number receives five hundred to one thousand calls per week and has resulted in the distribution of nearly one hundred thousand information kits, including a poster, a parent brochure, and a pop-up publication highlighting many professions that require math and science. The objective is not to persuade students to select a particular math-related field, but rather to persuade them to stay in the pipeline long enough to make informed decisions about their careers.

Based on the campaign's success, the National Science Foundation and the U.S. Department of Education asked NACME to partner with the National Council of Teachers of Mathematics and The Widmeyer Baker Group in developing *Figure This!* Designed to engage middle school students and their families in doing stimulating, high-quality math challenges together, *Figure This!* is a Web site filled with fun math-based activities as well as advice for parents on how to help their children get the most out of math. *Figure This!* and *Math Is Power* information can be found at www.figurethis.org and www.mathispower.org.

Figure 1. Representation of Groups in the U.S. Population (1995), the Incidence of Their Portrayal on Prime Time Television, and Their Representation as Scientists From Samples of Prime Time Television: 1994-98.



* Estimate not from U.S. Census data.
Source: Gerbner and Linson, Department of Commerce report,1999.

When the researchers looked at the extent to which women, minorities, and persons with disabilities were portrayed as scientists on prime time television, unsurprisingly they found that 75 percent of the scientists were white males. Figure 1 shows the representation of different groups in the U.S. population, the incidence of their portrayal on prime time television, and their representation among scientists from samples of prime time television between 1994 and 1998. As illustrated in the graph, females, most minorities, and persons with disabilities are underrepresented in the sciences, while white males, black males, and foreign nationals are overrepresented. The study concludes that if children "follow examples from television, there will be very few females and minorities in science occupations in the next century."

Speaking Out Against Stereotyping

It has been suggested that the negative depiction of scientists on television derives from what Carl Sagan referred to as the "dumbing down of America." When intellectual pursuits are undervalued, it becomes easier to pigeonhole scientists as odd or threatening. A review of current television shows that appeal to children reveals the common portrayal of bright students as socially inept and objects of ridicule ("dweebs" and "nerds").[11] A study done by the National Commission on Working Women examined more than 200 episodes of daytime and prime time television programs with adolescent female characters. It found that girls' physical appearances were shown as being more important than their brains and that intelligent girls were sometimes depicted as being social misfits, only attractive to intelligent boys who were also misfits.[12]

For the most part, the news media operate in a fundamentally different way from the entertainment media or advertising. While in recent years there has been a blurring of the line separating entertainment and news, a reporter's primary job is still to cover newsworthy events in an informational manner, not to shock, amuse, or promote a view or product. If there are fewer women, underrepresented minorities, and persons with disabilities among the ranks of scientists and engineers, then there will necessarily be fewer of them at work on groundbreaking projects, and this is not the news media's fault. Efforts to support diversity in SET professions will, *de facto*, help to improve diversity in SET news coverage.

Still, too often reporters and their editors offer the news in the form of headlines and stories that rely on easy and unflattering cliches to make a quick point. *Time* magazine published a cover story entitled " The Golden Geeks" that discussed the lives of new computer multimillionaires.[13] *Business Week* ran an article on the IT workforce that was subtitled "Send Nerds."[14] And a news story in the *Washington Post* referred to the pioneers of the Internet as " venerated propeller-heads."[15]

> "Popular images [of scientists]...are relevant to understanding how to recruit young people into science..."
>
> **Marcel C. LaFollette, Ph.D.**
> *Associate Research Professor*
> *George Washington University*

Deeply concerned about the detrimental public image of scientists and engineers, researchers and policymakers are advocating a broad national effort, perhaps a public relations or advertising campaign, to broaden the depictions of scientists by the image-makers on Madison Avenue and in Hollywood. They propose the formation of a coalition of several communities, including major science institutions, government agencies, private foundations, the entertainment industry, and the business community. Some have even suggested that scientists adopt techniques used by other groups such as racial/ethnic minorities, women, and gays, to lobby against stereotyping in television and movie scripts.[16]

The Commission strongly supports these approaches. Because children develop persistent attitudes towards scientists and engineers at such an early age, TV shows aimed at young children must be a major focus of such efforts. Attention must be given to increasing the representation of women, underrepresented minorities, and persons with disabilities among the images of scientists portrayed in these shows. And it goes without saying that prime time TV should be the principal instrument of change because of its broad reach, although other media, such as movies, newspapers, and magazines, should be targeted as well.

As can be seen in the foregoing sections of this report, the perception of women, underrepresented minorities, and persons with disabilities as people who do not engage in scientific or technical work severely hampers the access of these groups to SET careers, and impedes their progress if they do become SET professionals. Expanding the public image of scientists and engineers to include under-represented groups will help to increase their chances of succeeding in SET degrees and professions.

Public Image Recommendation

Identify or establish a body, representing public, nonprofit, and private sectors, to coordinate efforts to transform the image of the SET professions and their practitioners so that the image is positive and inclusive for women, underrepresented minorities, and persons with disabilities.

- Because several media campaigns to improve the image of scientists and engineers are already underway, our recommendation suggests that subsequent efforts build on and involve current campaigns, and also partner with natural allies such as underrepresented minority and women's groups, major science institutions, government agencies, trade organizations, and private foundations.

Sample measures of effectiveness include positive images represented in the Draw-a-Scientist Test, positive and increased media portrayal of underrepresented persons in science and engineering, and increased and well-positioned television airtime for these groups as they participate in SET professions.

NATIONWIDE ACCOUNTABILITY

"Before we once again seek to restate the problems...we need to consider that perhaps... [i]t is the structure of our institutions, agencies, societies, academies, and departments that must change. And rather than fixing blame, it may be far more productive to fix the system."

Shirley M. Malcom, Ph.D.
Director, Education and Human Resources Programs
American Association for the Advancement of Science

The lack of diversity in SET education and careers, as documented in this report, is nothing new. Stereotypes based on race, ethnicity, gender, and disability have long discouraged inquisitive minds whose bodies do not match the public image.

"We are losing ground by not tapping into the potential of all our groups. If we take some bold steps now, the rewards for our country and our citizens will be great."

Mary Ellen Duncan, Ph.D.
President, Howard Community College

Financial constraints continue to plague underrepresented minorities disproportionately and hinder their advancement into college and beyond. Women still bear the brunt of household work and family responsibility, with no commensurate support from workplace policies or culture. Persons with disabilities have only recently gained national attention as a group whose best contributions to society are too often stymied because of misconceptions about their abilities and physical barriers that could well be overcome, especially considering the technological resources now available.

The push toward greater diversity across job categories has always been a social imperative, but current economic and demographic realities bring a new urgency to the mission. The nation has a strategic need to achieve parity in its SET workforce. It is time—more than time—to move beyond a restatement of the issues and to establish a system of accountability that ensures real, measurable progress toward a scientific enterprise empowered by the best rather than simply by the traditional.

Nationwide Accountability Recommendation

Establish or identify a collaborative body to continue the efforts of the Commission through the development, coordination, and oversight of strong, feasible action plans.

The responsibility of this continuing body will be to promote and monitor progress toward the Commission's goal of supplying our nation's SET work force needs through the development of the human resources represented by women, underrepresented minorities, and persons with disabilities. This collaborative body (whose members will include high-level persons from federal and state government, industry, academe, and the nonprofit sector, as well as students and teachers) will carry on the work of this Commission by developing and overseeing comprehensive action plans, and by securing resources that will help in reaching the Commission's goal of domestic work force parity in SET.

The continuing body has four charges:

- Develop action items to implement the recommendations developed by the Commission.
- Further develop appropriate existing programs, using the recommendations of the Commission as a point of reference.
- Coordinate and assign actions/programs to appropriate sectors (government, industry, academe), and ensure funding and resources.
- Monitor progress through ongoing data compilation and analysis.

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COMMISSION MEMBERSHIP

The Commission was composed of eleven members appointed by the President, the majority and minority leaders of Congress, and the Chair and Vice Chair of the National Governors' Association. For biographies of each Commissioner, visit the Web site at www.nsf.gov/od/cawmset/members.htm.

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George Campbell, Jr. , Ph.D.
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Former President & CEO, NACME, Inc.
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Chairman of the National Governors' Association

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Rita Rodriguez, Ph.D.
Coordinator
June-September 2000

INTERAGENCY STEERING COMMITTEE

The Interagency Steering Committee of the Commission—comprised of senior officials at the federal agencies whose missions encompass human resources development in science, engineering, and technology—worked collaboratively to support the Commission in completing its examination of (1) the factors underlying the underparticipation in the SET enterprise of women, members of racial and ethnic minority groups, and persons with disabilities, and (2) the most effective strategies implemented by educators and employers to increase the recruitment, utilization, promotion, and retention of members of these groups.

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COMMISSION MEETINGS

In developing their report and recommendations, the Commission met a total of seven times. The Commission wishes to extend its thanks to the following individuals for their valuable contributions. Individuals listed below participated in Commission meetings through presentations and/or the submission of oral or written testimony.

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March 8-9, 2000
National Science Foundation
Arlington, VA

Linda Rosen, Ph.D.
National Commission on Mathematics and Science Teaching
for the Twenty-First Century

April 26-27, 2000
National Science Foundation
Arlington, VA

No presenters.

July 13, 2000
Congressional Press Briefing
Samuel Rayburn House Office Building
Washington, DC

Congresswoman Judy Biggert (R-IL)

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The Cooper Union for the Advancement of Science and Art

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Congresswoman Eddie Bernice Johnson (D-TX)

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Congresswoman Constance Morella (R-MD)

Congressman James Sensenbrenner (R-WI)

Public Law 105-255

105th Congress

An Act

To establish the Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development Act".

SEC. 2. FINDINGS.

The Congress finds the following:

(1) According to the National Science Foundation's 1996 report, Women, Minorities, and Persons with Disabilities in Science and Engineering—

  (A) women have historically been underrepresented in scientific and engineering occupations, and although progress has been made over the last several decades, there is still room for improvement;
  (B) female and minority students take fewer high-level mathematics and science courses in high school;
  (C) female students earn fewer bachelors, masters, and doctoral degrees in science and engineering;
  (D) among recent bachelors of science and bachelors of engineering graduates, women are less likely to be in the labor force, to be employed full-time, and to be employed in their field than are men;
  (E) among doctoral scientists and engineers, women are far more likely to be employed at 2-year institutions, are far less likely to be employed in research universities, and are much more likely to teach part-time;
  (F) among university full-time faculty, women are less likely to chair departments or hold high-ranked positions;
  (G) a substantial salary gap exists between men and women with doctorates in science and engineering;
  (H) Blacks, Hispanics, and Native Americans continue to be seriously underrepresented in graduate science and engineering programs; and
  (I) Blacks, Hispanics, and Native Americans as a group are 23 percent of the population of the United States, but only 6 percent are scientists or engineers.

(2) According to the National Research Council's 1995 report, Women Scientists and Engineers Employed in Industry: Why So Few?—

  (A) limited access is the first hurdle faced by women seeking industrial jobs in science and engineering, and while progress has been made in recent years, common recruitment and hiring practices that make extensive use of traditional networks often overlook the available pool of women;
  (B) once on the job, many women find paternalism, sexual harassment, allegations of reverse discrimination, different standards for judging the work of men and women, lower salary relative to their male peers, inequitable job assignments, and other aspects of a male-oriented culture that are hostile to women; and
  (C) women to a greater extent than men find limited opportunities for advancement, particularly for moving into management positions, and the number of women who have achieved the top levels in corporations is much lower than would be expected, based on the pipeline model.

(3) The establishment of a commission to examine issues raised by the findings of these two reports would help—

  (A) to focus attention on the importance of eliminating artificial barriers to the recruitment, retention, and advancement of women and minorities in the fields of science, engineering, and technology, and in all employment sectors of the United States;
  (B) to promote work force diversity;
  (C) to sensitize employers to the need to recruit and retain women and minority scientists, engineers, and computer specialists; and
  (D) to encourage the replication of successful recruitment and retention programs by universities, corporations, and Federal agencies having difficulties in employing women or minorities in the fields of science, engineering, and technology.

SEC. 3. ESTABLISHMENT.

There is established a commission to be known as the "Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development"' (in this Act referred to as the "Commission").

SEC. 4. DUTY OF THE COMMISSION.

The Commission shall review available research, and, if determined necessary by the Commission, conduct additional research to—

(1) identify the number of women, minorities, and individuals with disabilities in the United States in specific types of occupations in science, engineering, and technology development;
(2) examine the preparedness of women, minorities, and individuals with disabilities to—
  (A) pursue careers in science, engineering, and technology development; and
  (B) advance to positions of greater responsibility within academia, industry, and government;
(3) describe the practices and policies of employers and labor unions relating to the recruitment, retention, and advancement of women, minorities, and individuals with disabilities in the fields of science, engineering, and technology development;
(4) identify the opportunities for, and artificial barriers to, the recruitment, retention, and advancement of women, minorities, and individuals with disabilities in the fields of science, engineering, and technology development in academia, industry, and government;
(5) compile a synthesis of available research on lawful practices, policies, and programs that have successfully led to the recruitment, retention, and advancement of women, minorities, and individuals with disabilities in science, engineering, and technology development;
(6) issue recommendations with respect to lawful policies that government (including Congress and appropriate Federal agencies), academia, and private industry can follow regarding the recruitment, retention, and advancement of women, minorities, and individuals with disabilities in science, engineering, and technology development;
(7) identify the disincentives for women, minorities, and individuals with disabilities to continue graduate education in the fields of engineering, physics, and computer science;
(8) identify university undergraduate programs that are successful in retaining women, minorities, and individuals with disabilities in the fields of science, engineering, and technology development;
(9) identify the disincentives that lead to a disproportionate number of women, minorities, and individuals with disabilities leaving the fields of science, engineering, and technology development before completing their undergraduate education;
(10) assess the extent to which the recommendations of the Task Force on Women, Minorities, and the Handicapped in Science and Technology established under section 8 of the National Science Foundation Authorization Act for Fiscal Year 1987 (Public Law 99-383; 42 U.S.C. 1885a note) have been implemented;
(11) compile a list of all federally funded reports on the subjects of encouraging women, minorities, and individuals with disabilities to enter the fields of science and engineering and retaining women, minorities, and individuals with disabilities in the science and engineering workforce that have been issued since the date that the Task Force described in paragraph (10) submitted its report to Congress;
(12) assess the extent to which the recommendations contained in the reports described in paragraph (11) have been implemented; and
(13) evaluate the benefits of family-friendly policies in order to assist recruiting, retaining, and advancing women in the fields of science, engineering, and technology such as the benefits or disadvantages of the Family and Medical Leave Act of 1993 (29 U.S.C. 2001 et seq.).

SEC. 5. MEMBERSHIP.

(a) Number and Appointment.—The Commission shall be composed of 11 members as follows:

(1) One member appointed by the President from among for-profit entities that hire individuals in the fields of engineering, science, or technology development.
(2) Two members appointed by the Speaker of the House of Representatives from among such entities.
(3) One member appointed by the minority leader of the House of Representatives from among such entities.
(4) Two members appointed by the majority leader of the Senate from among such entities.
(5) One member appointed by the minority leader of the Senate from among such entities.
(6) Two members appointed by the Chairman of the National Governors Association from among individuals in education or academia in the fields of life science, physical science, or engineering.
(7) Two members appointed by the Vice Chairman of the National Governors Association from among such individuals.

(b) Initial Appointments.—Initial appointments shall be made under subsection (a) not later than 90 days after the date of the enactment of this Act.

(c) Terms.—

(1) In general.—Each member shall be appointed for the life of the Commission.
(2) Vacancies.—A vacancy in the Commission shall be filled in the manner in which the original appointment was made.

(d) Pay of Members.—Members shall not be paid by reason of their service on the Commission.

(e) Travel Expenses.—Each member shall receive travel expenses, including per diem in lieu of subsistence, in accordance with sections 5702 and 5703 of title 5, United States Code.

(f) Quorum.—A majority of the members of the Commission shall constitute a quorum for the transaction of business.

(g) Chairperson.—The Chairperson of the Commission shall be elected by the members.

(h) Meetings.—The Commission shall meet not fewer than 5 times in connection with and pending the completion of the report described in section 8. The Commission shall hold additional meetings for such purpose if the Chairperson or a majority of the members of the Commission requests the additional meetings in writing.

(i) Employment Status.—Members of the Commission shall not be deemed to be employees of the Federal Government by reason of their work on the Commission except for the purposes of—

(1) the tort claims provisions of chapter 171 of title 28, United States Code; and

(2) subchapter I of chapter 81 of title 5, United States Code, relating to compensation for work injuries.

SEC. 6. DIRECTOR AND STAFF OF COMMISSION; EXPERTS AND CONSULTANTS.

(a) Director.—The Commission shall appoint a Director who shall be paid at a rate not to exceed the maximum annual rate of basic pay payable under section 5376 of title 5, United States Code.

(b) Staff.—The Commission may appoint and fix the pay of additional personnel as the Commission considers appropriate.

(c) Applicability of Certain Civil Service Laws.—The Director and staff of the Commission may be appointed without regard to the provisions of title 5, United States Code, governing appointments in the competitive service, and may be paid without regard to the provisions of chapter 51 and subchapter III of chapter 53 of that title relating to classification and General Schedule pay rates, except that an individual so appointed may not receive pay in excess of the maximum annual rate of basic pay payable under section 5376 of title 5, United States Code.

(d) Experts and Consultants.—The Commission may procure temporary and intermittent services under section 3109(b) of title 5, United States Code, at rates for individuals not to exceed the maximum annual rate of basic pay payable under section 5376 of title 5, United States Code.

(e) Staff of Federal Agencies.—Upon request of the Commission, the Director of the National Science Foundation or the head of any other Federal department or agency may detail, on a reimbursable basis, any of the personnel of that department or agency to the Commission to assist it in carrying out its duties under this Act.

SEC. 7. POWERS OF COMMISSION.

(a) Hearings and Sessions.—The Commission may, for the purpose of carrying out this Act, hold hearings, sit and act at times and places, take testimony, and receive evidence as the Commission considers appropriate. The Commission may administer oaths or affirmations to witnesses appearing before it.

(b) Powers of Members and Agents.—Any member or agent of the Commission may, if authorized by the Commission, take any action which the Commission is authorized to take by this section.

(c) Obtaining Official Data.—The Commission may secure directly from any department or agency of the United States information necessary to enable it to carry out this Act. Upon request of the Chairperson of the Commission, the head of that department or agency shall furnish that information to the Commission.

(d) Mails.—The Commission may use the United States mails in the same manner and under the same conditions as other departments and agencies of the United States.

(e) Administrative Support Services.—Upon the request of the Commission, the Administrator of General Services shall provide to the Commission, on a reimbursable basis, the administrative support services necessary for the Commission to carry out its responsibilities under this Act.

(f) Contract Authority.—To the extent provided in advance in appropriations Acts, the Commission may contract with and compensate Government and private agencies or persons for the purpose of conducting research or surveys necessary to enable the Commission to carry out its duties under this Act.

SEC. 8. REPORT.

Not later than 1 year after the date on which the initial appointments under section 5(a) are completed, the Commission shall submit to the President, the Congress, and the highest executive official of each State, a written report containing the findings, conclusions, and recommendations of the Commission resulting from the study conducted under section 4.

SEC. 9. CONSTRUCTION; USE OF INFORMATION OBTAINED.

(a) In General.—Nothing in this Act shall be construed to require any non-Federal entity (such as a business, college or university, foundation, or research organization) to provide information to the Commission concerning such entity's personnel policies, including salaries and benefits, promotion criteria, and affirmative action plans.

(b) Use of Information Obtained.—No information obtained from any entity by the Commission may be used in connection with any employment related litigation.

SEC. 10. TERMINATION; ACCESS TO INFORMATION.

(a) Termination.—The Commission shall terminate 30 days after submitting the report required by section 8.

(b) Access to Information.—On or before the date of the termination of the Commission under subsection (a), the Commission shall provide to the National Science Foundation the information gathered by the Commission in the process of carrying out its duties under this Act. The National Science Foundation shall act as a central repository for such information and shall make such information available to the public, including making such information available through the Internet.

SEC. 11. REVIEW OF INFORMATION PROVIDED BY THE NATIONAL SCIENCE FOUNDATION AND OTHER AGENCIES.

(a) Provision of Information.—At the request of the Commission, the National Science Foundation and any other Federal department or agency shall provide to the Commission any information determined necessary by the Commission to carry out its duties under this Act, including—

(1) data on academic degrees awarded to women, minorities, and individuals with disabilities in science, engineering, and technology development, and workforce representation and the retention of women, minorities, and individuals with disabilities in the fields of science, engineering, and technology development; and

(2) information gathered by the National Science Foundation in the process of compiling its biennial report on Women, Minorities, and Persons with Disabilities in Science and Engineering.

(b) Review of Information.—The Commission shall review any information provided under subsection (a) and shall include in the report required under section 8—

(1) recommendations on how to correct any deficiencies in the collection of the types of information described in that subsection, and in the analysis of such data, which might impede the characterization of the factors which affect the attraction and retention of women, minorities, and individuals with disabilities in the fields of science, engineering, and technology development; and

(2) an assessment of the biennial report of the National Science Foundation on Women, Minorities, and Persons with Disabilities in Science and Engineering, and recommendations on how that report could be improved.

SEC. 12. DEFINITION OF STATE.

In this Act, the term "State" includes the several States, the District of Columbia, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, American Samoa, Guam, the Virgin Islands, and any other territory or possession of the United States.

SEC. 13. AUTHORIZATION OF APPROPRIATIONS.

There are authorized to be appropriated to carry out this Act—

(1) $400,000 for fiscal year 1999; and

(2) $400,000 for fiscal year 2000.

Approved October 14, 1998.

LEGISLATIVE HISTORY—H.R. 3007:

HOUSE REPORTS: No. 105-562, Pt. 1 (Comm. on Science).
CONGRESSIONAL RECORD, Vol. 144 (1998):
Sept. 14, considered and passed House.
Oct. 1, considered and passed Senate.

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